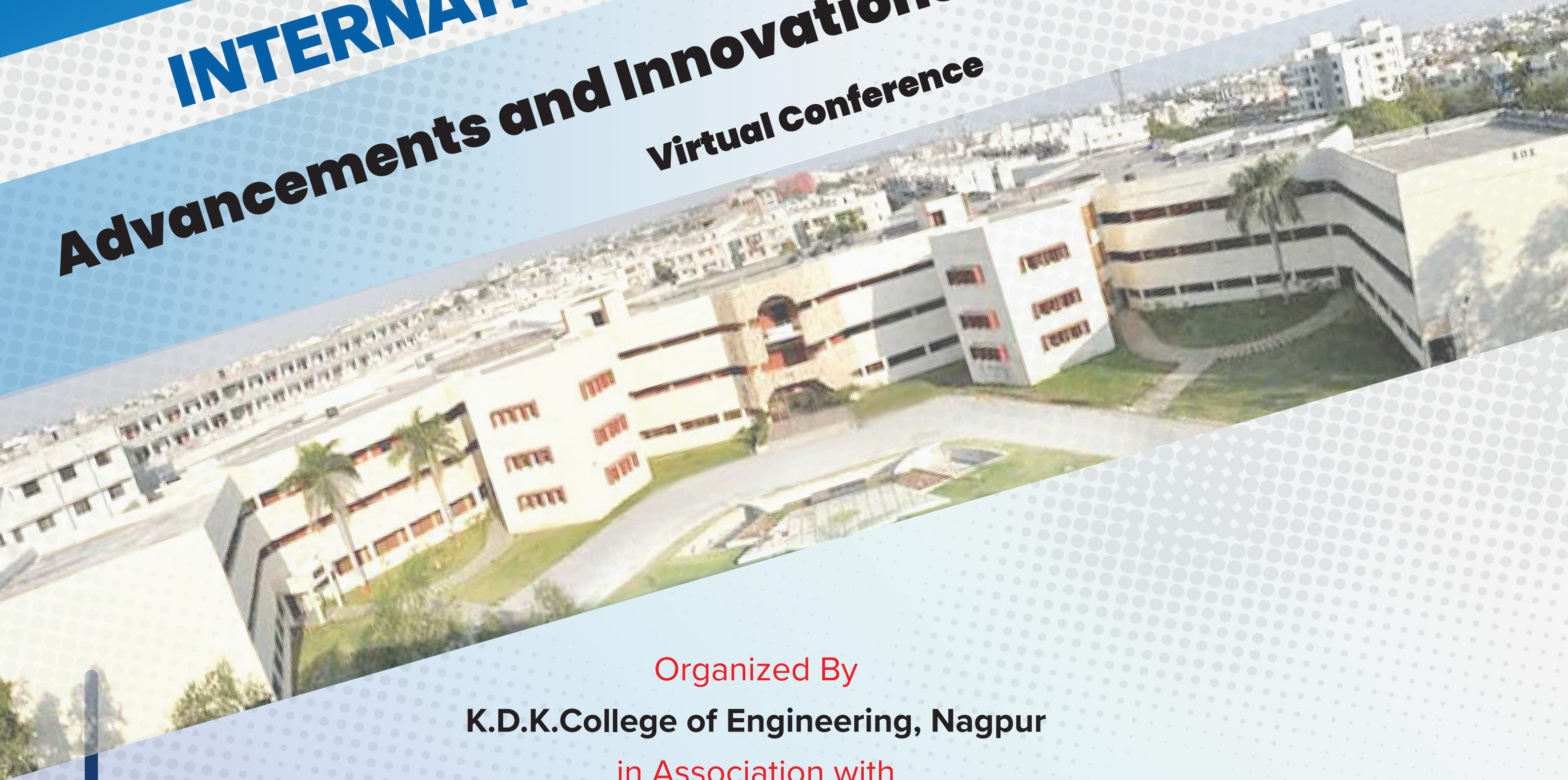
IC-AICE-2021

18th - 20th March 2021 | Nagpur

INTERNATIONAL CONFERENCE ON

Advancements and Innovations in Civil Engineering

Virtual Conference



Organized By

K.D.K.College of Engineering, Nagpur

in Association with

Institute For Engineering Research and Publication (IFERP)

American Society of Civil Engineers, Indian Section- Western Region (ASCE-ISWR)

Indian Society for Technical Education, New Delhi

Institution of Engineers India, Nagpur Local Centre (IEI-NLC)

Indian Concrete Institute, Nagpur Chapter (ICI-NC)

Indian Water Works Association, Nagpur Centre (IWWA-NC)

ISBN : 978-93-90214-19-8

IC-AICE - 2021

International Conference on

“Advancements and Innovations in Civil Engineering”

Nagpur, Maharashtra

18th to 20th March, 2021

Organized by:

K.D.K.College of Engineering, Nagpur

In Association with

Institute For Engineering Research and Publication (IFERP)
American Society of Civil Engineers (ASCE)
Indian Section- Western Region (ISWR)
Indian Society for Technical Education, New DelhiInstitution of Engineers India, Nagpur Local Centre (IEI-NLC)
Indian Concrete Institute, Nagpur Chapter (ICI-NC)
Indian Water Works Association, Nagpur Centre (IWWA-NC)

Preface

The "***International Conference on "Advancements and Innovations in Civil Engineering" (IC-AICE-2021) which is scheduled to take place on the 18th to 20th of March, 2021 organized by Department of Civil Engineering, K.D.K.College of Engineering, Nagpur*** in association with Institute For Engineering Research and Publication (IFERP), American Society of Civil Engineers, Indian Section- Western Region (ASCE-ISWR), Indian Society for Technical Education, New Delhi, Institution of Engineers India, Nagpur Local Centre (IEI-NLC), Indian Concrete Institute, Nagpur Chapter (ICI-NC), Indian Water Works Association, Nagpur Centre (IWWA-NC)

K.D.K.College of Engineering has a sprawling student –friendly campus with modern infrastructure and facilities which complements the sanctity and serenity of the major city of Nagpur in Maharashtra

The "***International Conference on "Advancements and Innovations in Civil Engineering"*** was a notable event which brings Academia, Researchers, Engineers, Industry experts and Students together.

The purpose of this conference is to discuss applications and development in area of **"Civil Engineering"** which were given International values by ***Institute For Engineering Research and Publication (IFERP).***

The International Conference attracted over 173 submissions. Through rigorous peer reviews 110 high quality papers were recommended by the Committee. The Conference aptly focuses on the tools and techniques for the developments on current technology in civil engineering.

We are indebted to the efforts of all the reviewers who undoubtedly have raised the quality of the proceedings. We are earnestly thankful to all the authors who have contributed their research works to the conference. We thank our Management for their wholehearted support and encouragement. We thank our Principal for his continuous guidance. We are also thankful for the cooperative advice from our advisory Chairs and Co-Chairs. We thank all the members of our local organizing Committee, National and International Advisory Committees.

IC – AICE 2021

FOREWORD

Shri Rajendra Mulak,
Hon'ble Secretary, KDKCE
Patron, IC-AICE-2021

I congratulate KDK College of Engineering, more particularly, the Civil Engineering Department for holding this Virtual **International Conference on Advancements and Innovations in Civil Engineering (IC-AICE-2021) from 18th to 20th March 2021**. This is the third international conference that is being organized in the institute by Civil Engineering Department. I am sure about the conference that it will serve an effective platform for the technocrats to share their ideas and research. I always encourage to such type of event, which eventually make the society aware about technological developments.

I wish every success to the conference.

(**Rajendra Mulak**)

FOREWORD

Shri Yashraj R Mulak
Hon’ble Treasurer, KDKCE
Patron, IC-AICE-2021

It feels proud to mention here that the Department of Civil Engineering is organizing Virtual **International Conference on Advancements and Innovations in Civil Engineering (IC-AICE-2021) from 18th to 20th March 2021**. In the past, the department has successfully organized International Conferences on ‘Innovative Realms in Civil Engineering-2018’ (IRICE-2018) and Emerging Trends in Civil Engineering (ETSE-2017), and online International STTP – ATMCE2020, which were a grand success in the entire domain.

I am confident that this conference would also see the galaxy of technocrats, researchers, and professional in the field of Civil Engineering and will share their knowledge and wisdom.

I wish lots of success to the conference.

(**Yashraj Mulak**)

FOREWORD

Dr D.P. Singh
Principal, KDKCE, Nagpur
Patron, IC-AICE-2021

I am, indeed, proud and privileged that department of Civil Engineering KDKCE is organizing Three days International Conference on **Advancements and Innovations in Civil Engineering (IC-AICE-2021) from 18th to 20th March 2021** at KDKCE Nagpur **on Online Platform**. The conference is jointly organized by IFERP, American Society of Civil Engineers, Indian Section – Western Region (ASCE-ISWR), Indian Society for Technical Education (ISTE) New Delhi, Institution of Engineers (I) Nagpur Local Chapter, Indian Concrete Institute Nagpur Centre, and Indian Water Works Association (IWWA) Nagpur Center.

I take this opportunity to brief about KDKCE. The Karmavir Dadasaheb Kannamwar College of Engineering, Nagpur, established in 1984 by Backward Class Youth Relief Committee (BCYRC), is one of the leading engineering colleges in Maharashtra State, approved by AICTE, New Delhi and DTE Maharashtra and affiliated to Rashtrsant Tukadoji Maharaj Nagpur University, Nagpur. Government of Maharashtra has conferred 'A' Grade on the basis of excellence & adequate infrastructure as well as academic achievements of students and faculty. The college runs Six Undergraduate courses, Three Postgraduate courses in Civil Engineering, Mechanical Engineering, and Master of Business Administration, and Two Research Center in Civil Engineering & Mechanical Engineering leading to Ph.D. with total Intake capacity of 666. The National Board of Accreditation (NBA) has accredited Five U. G. Courses viz. Civil, Mechanical, Electrical, Electronics and Telecommunication Engineering, and Computer Science & Engineering. The Civil Engineering and Mechanical Engineering were accredited by NBA two times earlier i.e. in 2002 & 2008, whereas Electrical Engineering was accredited by NBA in 2008. National Assessment and Accreditation Council (NAAC) also accredited the college. The Vision of the college is ***"Service to the Society through Quality Technical Education"***. Which aptly suits with the dedication and perseverance of faculty and all stakeholders.

With the whole-hearted support from the management of KDKCE, the college is taking stride in organizing such event to provide platform to the academician, researchers and professional. This conference will also see galaxy of such person exchanging their knowledge and findings in the field of civil engineering.

I congratulate Civil Engineering Department for taking efforts in organization of IC-AICE-2021 and express my sincere thanks to experts, keynote speakers for their valuable deliberations, and authors of papers, delegates, participants for their valuable contributions. I also extend my thanks to the management of IFERP, ASCE-ISWR, ISTE, ICI, IE (I) and IWWA for joining their hands in the organization of IC-AICE-2021.

My best wishes to the entire team of IC-AICE-2021.
(**Dr. D P Singh**)

FOREWORD

Dr Avinash M Badar
Vice Principal, KDKCE, Nagpur
Conference Chair, IRICE-2018

It gives me immense pleasure to announce the organization of Three-Days Online **International Conference on Advancements and Innovations in Civil Engineering (IC-AICE-2021)** by the Department of Civil Engineering, KDK College of Engineering, Nagpur on 18th – 20th March 2021 at KDKCE Nagpur. The conference is jointly organized by IFERP, American Society of Civil Engineers, Indian Section – Western Region (ASCE-ISWR), Indian Society for Technical Education (ISTE) New Delhi, Institution of Engineers (I) Nagpur Local Chapter, Indian Concrete Institute Nagpur Centre, and Indian Water Works Association (IWWA) Nagpur Center.

India is going through the transitional phase from the conventional growth to the smart growth. Many cities are enveloped into the smart city concept wherein, the innovative inputs are given in infrastructure construction with more emphasis on sustainable development. Therefore, it is inevitable to congregate all such spearheads *viz.* Academician, Researcher, Consultants, Professional, Practitioner, etc, at one platform to exchange their innovative ideas in various domains of Civil Engineering.

The International Conference (IC-AICE-2021) would be witnessing experts from oversea, premier institutions like IITs and NITs to share their knowledge and experience. I, therefore, take this opportunity to express my gratitude to all the luminaries for their valuable presence. I also extend my gratitude to authors of papers, delegates for their valuable contribution in the conference.

The papers to be presented in this conference are carefully reviewed and selected for presentation, which, I believe will make a significant contribution in the fields of Civil Engineering. During all the presentations, evaluation will be done by eminent technical chair & co-chair, which will pave the way for awarding best paper in various categories. I owe my thanks to the members of the Technical chair & co-chair for their support. We are also indebted to many individuals and organizations that made this event happen, namely to our supporting organizations, staff, who handled the logistics and worked to make this event a success, and to the technical and financial sponsors. I hope you will find this conference, a useful for presenting new ideas, results and recent findings in the fields of civil engineering.

I wish every success to entire crew of the IC-AICE-2021 for all their efforts in organizing the conference and making it a grand success. I express my gratitude to Chairman, Secretary, and Treasurer of our KDK College for encouraging in the organization of this conference. I also acknowledge the cooperation from IFERP, ASCE-ISWR, ISTE, IEI Nagpur Local Centre, ICI Nagpur Centre, IWWA, Nagpur Center.

(**Dr. Avinash Badar**)

Institute For Engineering Research & Publication

Unit of Technoarete Research and Development Association

IFERP

connecting engineers... developing research

Rudra Bhanu Satpathy

Chief Executive Officer

Institute For Engineering Research and Publication.

On behalf of ***Institute For Engineering Research and Publications (IFERP)*** in association with ***K.D.K.College of Engineering, Nagpur*** & ***American Society of Civil Engineers, Indian Section- Western Region (ASCE-ISWR)Indian Society for Technical Education, New Delhi, Institution of Engineers India, Nagpur Local Centre (IEI-NLC)Indian Concrete Institute, Nagpur Chapter (ICI-NC)Indian Water Works Association, Nagpur Centre (IWWA-NC)***. I am delighted to welcome all the delegates and participants around the globe for the ***"International Conference on "Advancements and Innovations in Civil Engineering" (IC-AICE-2021)"*** Which will take place from ***18^{th} to 20^{th}March 2021***

It will be a great pleasure to join with Engineers, Research Scholars, academicians, and students all around the globe. You are invited to be stimulated and enriched by the latest in engineering research and development while delving into presentations surrounding transformative advances provided by a variety of disciplines.

I congratulate the reviewing committee, coordinator **(IFERP, KDK, ASCE-ISWR, IST New Delhi, IEI-NLC, ICI-NC & IWWA-NC)** and all the people involved for their efforts in organizing the event and successfully conducting the International Conference and wish all the delegates and participants a very pleasant experience on Virtual Mode.

Sincerely,

Rudra Bhanu Satpathy

044-42918383

Email: info@iferp.in
www.iferp.in

Girija Towers, Arumbakkam, Chennai - 600106

Er.R.B.Satpathy
CEO, IFERP
Conference Co-Chair, IC-AICE-2021

IFERP is the largest Professional body for Engineering professionals in India and all across the globe, established in 2000, with headquarters at Chennai, India. IFERP reach extends to every part of the globe, with more than 14,000 professional members and 18,000 student members. IFERP's growing membership has led to the increase in members from Europe, Asia, Australia and Africa, fostering networking opportunities that strengthen ties within and across countries and technical communities. Their actions enhance IFERP's ability to raise awareness in the field of recent trends in the development of engineering, science and technology and the important technical, educational, and social issues around the world.

IFERP connect engineers, exchange global innovation and act as a bridge between Researchers & Academicians by organizing International/National Conferences, Seminar, FDP, Faculty Exchange, STTPs, etc. Presently, IFERP is joined hands with Department of Civil Engineering, K D K College of Engineering, Nagpur in organizing **International Conference on Advancements and Innovations in Civil Engineering – (IC-AICE-2021)** from 18th March 2021 to 20th March 2021 at KDKCE Campus, Nagpur. Other eminent organizations like American Society of Civil Engineers, Indian Section – Western Region (ASCE-ISWR), Indian Society for Technical Education (ISTE) New Delhi, Institution of Engineers (I) Nagpur Local Chapter, Indian Concrete Institute Nagpur Centre, and Indian Water Works Association (IWWA) Nagpur Center are also supporting in the organization of the conference IC-AICE-2021. The Three Day Virtual Conference will provide the platform to the academician, professionals, researchers, to display their research study, case study, findings, etc., along with keynote addresses by finest academicians/researchers/practitioners across the world.

On behalf of IFEP, I use this platform to make an appeal to all the delegates to make most of the opportunity and get enrich with latest development and innovations in the field of Civil Engineering. I am sure this conference will see the epitome of success.

All the very best to the entire crew of IC-AICE-2021

Er.R.B.Satpathy
Conference Co-Chair, IC-AICE-2021

PREFACE

Er. Ravindra Ringshia
President, American Society of Civil Engineers (ISWR)
Conference Co-Chair – IC-AICE-2021

I am delighted, being associated with the Department of Civil Engineering, KDK College of Engineering in organizing Three Days International Conference on **Advancements and Innovations in Civil Engineering** (IC – AICE – 2021) on March 18 -20, 2021.

I am learned that IC-AICE-2021 boasts all the related fields of civil engineering on which advancements and innovations will be discussed during the course of technical presentation. Furthermore, the conference will witness the keynote addresses of the finest academician, professional across the globe, which makes the conference truly global.

I am sure the participants are going to be benefitted tremendously by the enrichment of knowledge in the respective domain of civil engineering.

I call upon all the researchers, practitioners, academician, and professionals to join the prestigious international conference IC-AICE-2021 and enrich yourself with advancements and innovations in the field of civil engineering.

My best wishes to all the organizing team of IC-AICE-2021 and entire KDKCE Civil Engineering Department.

Er. Ravindra Ringshia
President, American Society of Civil Engineers (ISWR)
Conference Co-Chair – IC-AICE-2021

PREFACE

Prof. (Dr) Rakesh Shrivastava
Chairman, I E(I) Nagpur Local Centre
Conference Co-Chair – IC-AICE-2021

It gives me immense pleasure to get connected with all esteemed Personalities, Organisations and Participants of this Three Days Online International Conference on **"Advancements and Innovations in Civil Engineering"** (IC – AICE – 2021) on March 18 -20 ,2021.

The Conference has attracted a truly global response and several stalwarts have agreed to deliver Plenary sessions on almost everything related to modern Civil Engineering. We have received umpteen numbers of Quality Research Papers from all across the world. It will literary be a Technological feast for all the participating professionals.

All the Organising Institutions led by KDK College of Engineering, Nagpur have put up a commendable job in putting up a grand show in the field of Civil Engineering.

We take this opportunity to invite you all to this prestigious event and enjoy this platform to enrich your knowledge and build future networks.

Welcome One and All!

Prof. (Dr) Rakesh Shrivastava
Conference Co-Chair – IC-AICE-2021

Er. Arun Uttarwar
Chairman,
Indian Concrete Institute, Nagpur Chapter
Conference Co-Chair , IC-AICE-2021

Indian Concrete Institute is one of the leading professional bodies in India, catering to the professional needs of individuals and organizations involved in Concrete. Being a non-profit Organization, it is dedicated to the cause of Disseminating Knowledge on Concrete, to Promote Concrete Technology and Construction and to address the Research Needs of Concrete. ICI Nagpur chapter is a vibrant chapter amongst the various chapters spread across India and we are proud to organize International & National Conferences, Workshops, and Expert Lectures by persons of Eminence on various national important days. KDKCE students' chapter is also awarded with Best Emerging Student Chapter of ICI at national level.
Contributions and active support from members of the Institutions, Govt. / Semi-Govt./ Private Organizations, Industries and Engineering Colleges in and around Nagpur, has resulted in phenomenal development of the Centre, which is evident from the infrastructural facilities available.

Three Days Online International Conference on **International Conference on Advancements and Innovations in Civil Engineering (IC-AICE-2021)** by the Department of Civil Engineering, KDK College of Engineering, Nagpur on 18th , 19th & 20th March 2021 at KDKCE Nagpur. The conference is organized in association with IFERP, American Society of Civil Engineers, Indian Section – Western Region (ASCE-ISWR), Indian Society for Technical Education (ISTE) New Delhi, Institution of Engineers (I) Nagpur Local Chapter, Indian Concrete Institute Nagpur Centre, and Indian Water Works Association (IWWA) Nagpur Center, will be absolute success. Eminent personalities are expected to participate in the deliberations. I am sure, this conference will benefit the academicians, researchers, industrial professional of civil engineering domain, etc. The discussions and presentations in the conference will open doors for new ideas and practices based on experiences in the field of civil constructions.

On this occasion, I as a Chairman of ICI Nagpur chapter, extend my greeting to everyone.

Er. ARUN UTARWAR
Conference Co-Chair , IC-AICE-2021

Er. N M Bangare

Chairman,
Indian Water Works Association, Nagpur Centre
Conference Co-Chair , IC-AICE-2021

I Congratulate Deptt of Civil Engineering , KDK College of Enginnering for initiating in organising Three-Days Online International Conference on **International Conference on Advancements and Innovations in Civil Engineering (IC-AICE-2021)** on 18th – 20th March 2021. This platform will definitely bring experts in the field of Engineering at one place and deliberate on various aspects. The theme of the Conference will surely find interest among the civil engineers to dwell on their topic of interest. Eminent personalities are expected to participate in the deliberations. I am sure; this conference will benefit the industries, practicing engineers, consultant and researchers.

I take this opportunity to extend my wishes to everyone to enrich with the knowledge.

Er. N M Bangare
Conference Co-Chair , IC-AICE-2021

ACKNOWLEDGEMENT

Dr Valsson Varghese
Professor & Head, Deptt of Civil Engg, KDKCE
Convener, IC - AICE 2021

KDK College of Engineering (KDKCE) and Institute for Engineering Research and Publication (IFERP), in association with, American Society of Civil Engineers, Indian Section – Western Region (ASCE-ISWR), Indian Society for Technical Education (ISTE) New Delhi, Institution of Engineers (I) Nagpur Local Chapter, Indian Concrete Institute Nagpur Centre, and Indian Water Works Association (IWWA) Nagpur Center, organizing three days online International Conference on **International Conference on Advancements and Innovations in Civil Engineering – (IC-AICE-2021)** by the Department of Civil Engineering, KDK College of Engineering, Nagpur on 18th – 20th March 2021 at KDKCE Nagpur. The aim of the conference is to provide an opportunity for exchanging technological advancements & innovations and scientific research in different domains of Civil Engineering. It would serve the platform for Professionals, Academicians, Scientists and Researchers, to share their knowledge, expertise and experiences in various concepts and innovations in the present scenario. KDKCE has earlier organised International Conference ETSE-2017, IRICE -2018, and International STTP on ATMCE-2020.

Civil engineering is the oldest engineering discipline, which encompasses with the built environment much of what defines modern civilization. Civil engineering is the fusion of engineering (the soundness of infrastructures), design (CAD sketches) and art (designing aesthetic structures) and is backbone of comprehensive development of country. Civil engineering is progressing at a fast pace as are other technologies. The works include roads, bridges, buildings, dams, water reservoirs canals, water supply and numerous other facilities that affect the life of human beings Civil engineers are vital to the functioning of advanced societies. Civil engineering is an exciting profession because at the end of the day you can see the results of your work, whether this is a completed bridge, a high-rise building, a subway station, or a hydroelectric dam. Hence, studying and understanding various fields of civil engineering is the essence of time.

Research papers are invited from faculties, Research Scholars, Scientists, and Practitioners working in varied fields of civil engineering.

The Conference proceeding along with CD contains the technical papers from Expert Civil Engineering consultants, Academicians, Research scholars, students etc. the conference is a good opportunity for the participants interact online from different places of India to present and discuss topics in their respective research areas. Various technical sessions of Three days IC-AICE-2021 reflects different ideas and methods of theme in a lively way.

I would like to thank all the participants for their contributions to the conference proceedings. Many thanks are due to all the sponsors, supporters for their support and hospitality, which allowed all the participants to feel more at home.

My special thanks go to my colleagues, committee members for their untiring contributions for the conference in preparing this proceeding volume.

It is our pleasant duty to acknowledge the support and cooperation's from the office bearers of IFERP, ASCE-ISWR, ISTE, IEI(I)-NLC, ICI-NC, & IWWA-NC, The Management of KDKCE for the organization of this Conference.

Dr Valsson Varghese
Convener IC-AICE- 2021

From the desk of Organizing Secretary

Prof. Mahendra Umare
Assistant Professor, CED, KDKCE
Organizing Secretary, IC-AICE-2021

Prof S.R.Satone
Assistant Professor , CED, KDKCE
Organizing Secretary IC-AICE-2021

Prof P.S.Randive
Assistant Professor , CED, KDKCE
Organizing Secretary IC-AICE-2021

We, on behalf of organizing committee, welcome you all to the Virtual International Conference on **International Conference on Advancements and Innovations in Civil Engineering – (IC-AICE-2021)** on 18thth – 20th March 2021, being jointly organized by the Department of Civil Engineering, KDKCE, in association with IFERP, American Society of Civil Engineers, Indian Section – Western Region (ASCE-ISWR), Indian Society for Technical Education (ISTE) New Delhi, Institution of Engineers (I) Nagpur Local Chapter, Indian Concrete Institute Nagpur Centre.

The conference is aimed at bringing the research and innovative ideas in the field of civil engineering. The themes have been chosen to cater all the domain of civil engineering.

The conference will be witnessing the experts from USA, Mexico, Philippines, Iraq, Malaysia, Australia, and Indian, other premier institute like IITs for delivering keynote address and sharing their technical wisdom. The conference will provide a unique forum for exchange of ideas, knowledge, and opportunities in the field of civil engineering.

The information about the conference was largely sent using virtual platform. We have received appreciable number of enquiries and registrations. The abstract was asked to submit electronically, which was reviewed and invited for full paper submission. The full text also has been peer reviewed and selected for presentation. The research articles received for selection and presentation in the conference will be one of the effective reflections of its scientific, academic, and technological contribution.

However, the success of meticulously organized program will be nothing without the active participation and support of all the participants. It is our humble and sincere request to you all to come forward with your contributions by way of your virtual presence.

The organizing committee has left no stone unturned to ensure that the conference turns out to be an occasion from which all of you carry back lingering memories of technological enrichment.

We express our heartfelt thanks to all the experts, authors of the papers and entire team of IC-AICE-2021 for their valuable contribution towards the conduction of the conference.

We once again welcome you all and wish you to have a great experience.

Thanking you,

(Organizing Secretary)

IC-AICE-2021

International Conference on "Advancements and Innovations in Civil Engineering"

Keynote Speaker

Dr. Philip P. Ermita, PIE, ASEAN Eng.

Dean, College of Engineering

University of Pepretual Help System DALTA

Calamba City, Laguna, Philippines

Fellow, Institute for Engineering Research and Publication

EDUCATIONAL BACKGROUND

- Doctor of Philosophy in Engineering Management Nueva Ecija University of Science and Technology Cabanatuan City, Nueva Ecija, Philippines
- Master of Engineering Major in Industrial Engineering Adamson University
- San Marcelino, Manila, Philippines
- Diploma in Business Administration De La Salle University – Dasmariñas Dasmariñas City, Cavite, Philippines
- Bachelor of Science in Industrial Engineering De La Salle University – Dasmariñas Dasmariñas City, Cavite, Philippines

ACADEMIC WORK EXPERIENCE

- Professor / Dean College of Engineering

University of Perpetual Help System DALTA Calamba Campus Calamba City, Laguna, Philippines

- Special Lecturer (Associate Professorial Level III)

College of Engineering, Graduate School and Open University Polytechnic University of the Philippines - Manila

- Part Time Faculty

Graduate School and College of Engineering University of Perpetual Help System Laguna Binan, Laguna, Philippines

- Assistant Professor / Associate Dean

College of Engineering, Architecture and Technology De La Salle University – Dasmariñas

City of Dasmariñas, Cavite, Philippines

INDUSTRY WORK EXPERIENCE

Project Specialist

SPi Technologies

Sto. Nino, Paranaque City, Philippines

MESSAGE

On behalf of the IC-AICE-2021 organizing committee, I am delighted to inform and invite everyone to the upcoming International Conference on Advancements and Innovations in Civil Engineering 2021. I believe that the organizing committee have chosen a venue that guarantees a successful technical conference hosted by K.D.K College of Engineering Nagpur. Definitely, we will be having an exciting program in the conference that will allow members to extend our network, share expertise and jointly explore current and future research directions in the new normal. Looking forward to see you all in this another productive and fun-filled time virtual conference.

Dr. Philip P. Ermita, PIE, ASEAN Eng.

International Conference on "Advancements and Innovations in Civil Engineering" (IC-AICE-2021)
18th - 20th March 2021

Reimagining and Rethinking Engineering Education: A Key in Technological Innovation in Engineering Transformation

DR. PHILIP P. ERMITA, PIE, ASEAN Eng.
Dean, College of Engineering
University of Perpetual Help System DALTA
Laguna, Philippines
philip.ermita@perpetualdalta@edu.ph

The word engineer originates from the *LATIN* term ***ingerare***, meaning to ***INVENT, CREATE** or **to REGULATE***

Is ENGINEERING a priority program?

CHED SCHOLARSHIP 2020
List of Priority Courses

- Agricultural and Biosystems Engineering
- Architecture
- Ceramic Engineering
- Chemical Engineering
- Civil Engineering
- Computer Engineering
- Electrical Engineering
- Electronics Engineering/Electronics and Communications Engineering
- Food Engineering
- Geodetic Engineering
- Industrial Engineering
- Manufacturing/ Production Engineering
- Marine Engineering
- Marine Transportation
- Materials Engineering
- Mechanical Engineering
- Mechatronics Engineering
- Metallurgical Engineering
- Mining Engineering
- Petroleum Engineering
- Robotics Engineering
- Sanitary Engineering
- Structural Engineering

Is ENGINEERING a priority program?

Is there a DEMAND for Engineers?

How Engineers are Working Through the Coronavirus Pandemic
Apr 9, 2020 ~ Terry Persun

Companies also need to ensure that their IT infrastructure can accommodate work that has to be done remotely—and can do it securely.

Engineers are implementing new work guidelines to continue production during the COVID-19 pandemic

Source: www.asme.org

4 WAYS ENGINEERING could change after the Covid-19 Pandemic
29 Jun 2020 - Professional Engineering

1. COLLABORATION

The engineering response to the sudden demands of building ventilators, making personal protective equipment or creating new hospital capacity, companies and institutions from across the spectrum came together in a spirit of COLLABORATION.

Source: www.imeche.org

4 WAYS ENGINEERING could change after the Covid-19 Pandemic
29 Jun 2020 - Professional Engineering

2. NEED FOR SPEED

- Engineers demonstrated their full capacity when restrictions were lifted, creating prototypes in days and complete devices in weeks.
- "It's an amazing response, and a great example of how engineers can respond, when some of the barriers are removed, really quickly."

Source: www.imeche.org

4 WAYS ENGINEERING could change after the Covid-19 Pandemic
29 Jun 2020 - Professional Engineering

3. HOME - WORKING

- A Professional Engineering survey found that 18% of respondents reported no impact on their efficiency while working at home, with a similar number reporting no negative impact on their ability to perform technical engineering tasks.

Source: www.imeche.org

4 WAYS ENGINEERING could change after the Covid-19 Pandemic
29 Jun 2020 - Professional Engineering

4. NEW FOCUS

- There will be increased demand for engineering that fights, prevents and treats diseases, such as ventilators, anti-bacterial surfaces, temperature monitoring devices and other high-tech solutions.

Source: www.imeche.org

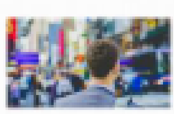
Top 5 job skills to future proof Engineering career post-Covid

1. Data Job opportunities for data engineers, data analysts, data scientists, and ML/AI engineers were growing steadily.

2. Cloud The COVID-19 pandemic is likely to accelerate cloud migration even more. We can foresee a greater demand for cloud architects and cloud IT admins.

3. Cybersecurity As cybersecurity becomes more critical, we will see a much greater demand for security architects and ethical hackers.

4.Digital Marketing In turn, this will result in greater demand for PPC practitioners, digital brand managers, content & SEO experts, CRM, and email marketing specialists.



5.Business Analysts Estimates from the U.S. Bureau of Labor Statistics, demand for management analysts, including business analysts, is likely to grow 14 percent, between 2018 to 2028.

Source: Hindustantimes(May, 2020)

Reimagining and Rethinking Engineering Education

- New MIT report takes a worldwide look at the future of how engineers are trained.
- Engineers will address the complex societal challenges of the 21st century by building a new generation of machines, materials, and systems.
- Targeting Engineering education at the industries of the future rather than industries of the past

Source: news.mit.edu/2018/reimagining-and-rethinking-engineering-education-0327

Reimagining and Rethinking Engineering Education

- Some key challenges facing engineering education, and in some cases higher education as a whole.
- These include aligning the goals of national governments and higher education,
- delivering student-centered learning to large student cohorts,
- Setting up faculty appointment and promotion systems that better reward high-quality teaching.

Source: news.mit.edu/2018/reimagining-and-rethinking-engineering-education-0327

Three Trends Defining the Future of Engineering Education.

- The first is a tilting of the global axis of engineering education leadership so it is less focused on U.S. and northern European institutions.
- The second is a shift toward programs that integrate student-centered learning with a curriculum oriented to the pressing challenges of the 21st century — societal, environmental, and technological
- The third is the emergence of a new generation of leaders with the capacity to deliver student-centered curricula at scale.

Source: news.mit.edu/2018/reimagining-and-rethinking-engineering-education-0327

New Engineering Education Transformation

Renewable Energy Machines	Combat climate change by designing and building green energy production, conversion, storage, and transmission systems.
Advanced Materials Machines	Explore the novel materials, technologies, and processes that will define the future of fabrication and manufacturing.
Autonomous Machines	Design, build and deploy electromechanical systems, electronics, software, and autonomy algorithms for real-world robots.
Digital Cities	Prepare to plan and build the cities of the future by immersing them in the emerging intersections of computer science and urban planning.
Living Machines	Discover, build and engineer living systems for broad applications in biotechnology and medical devices.

Source: https://neet.mit.edu/threads

Setting The Standard Worldwide

ABET
Accreditation Board for Engineering and Technology

- ABET accreditation provides assurance that a college or university program meets the quality standards of the profession for which that program prepares graduates.
- ABET accredit programs, not institutions.
- ABET provide specialized accreditation for post-secondary programs within degree-granting institutions already recognized by national or regional institutional accreditation agencies or national education authorities worldwide.
- To date, ABET has accredited 4,144 applied and natural science, computing, engineering and engineering technology programs at 812 colleges and universities in 32 countries worldwide.

Source: https://www.abet.org/accreditation/

Setting The Standard Worldwide

ABET
Accreditation Board for Engineering and Technology

What is ABET Accreditation?

ABET accreditation is not a ranking system; rather, it is a form of quality assurance, declaring to the relevant professional community and to the world at large, that a program meets the quality standards set by the technical profession.

ABET accreditation applies to **programs** only, not degrees, departments, colleges, institutions, or individuals.

ABET is a federation of member professional and technical societies. These societies and their individual members collaborate through ABET to develop quality standards, known as **ABET Criteria**, on which ABET review teams base their evaluations of applied science, computing, engineering, and engineering technology programs.

Setting The Standard Worldwide

ABET Accredited Worlwide

Source: https://www.abet.org/accreditation/

Setting The Standard Worldwide

....in the Philippines

Setting The Standard Worldwide

The CDIO™ INITIATIVE is an innovative educational framework for producing the next generation of engineers.

- The framework provides students with an education stressing engineering fundamentals set in the context of Conceiving — Designing — Implementing — Operating (CDIO) real-world systems and products. Throughout the world, CDIO Initiative collaborators have adopted CDIO as the framework of their curricular planning and outcome-based assessment.
- The CDIO Initiative was developed with input from academics, industry, engineers, and students and was specifically designed as a template that can be adapted and adopted by any university engineering school.
- CDIO is currently in use in university aerospace, applied physics, electrical engineering, and mechanical engineering departments.

Source: http://www.cdio.org/about

Setting The Standard Worldwide

12 CDIO STANDARDS:

1. CDIO as the Context
2. Learning Outcomes
3. Integrated Curriculum
4. Introduction to Engineering
5. Design-Implement Experience
6. Engineering Workspaces
7. Integrated Learning Experiences
8. Active Learning
9. Enhancement of Faculty CDIO Competence
10. Enhancement of Faculty Teaching Competence
11. Learning Assessment
12. Programme Evaluation

Source: http://www.cdio.org/about

Setting The Standard Worldwide

Project-Based Learning in Engineering Education

Source: http://www.cdio.org/about

Setting The Standard Worldwide

Project-Based Learning in Engineering Education

CONCLUSION

Join 115 participating members worldwide!

Source: http://www.cdio.org/about

Setting The Standard Worldwide

Project-Based Learning in Engineering Education

CONCLUDING REMARKS

- The CDIO approach provides a reference model for engineering education where professional practice and innovation is focused
- The CDIO approach is codified in the CDIO syllabus and standards. CDIO elements can be used as an integrated set or piecewise, are subject to adaptation to local context etc
- CDIO is an open endeavor – you are all welcome to participate and contribute - 97 universities worldwide are now members of the CDIO Initiative
- To learn more, visit www.cdio.org or read *Rethinking Engineering Education: The CDIO Approach* by Crawley, Malmqvist, Ostlund, & Brodeur, 2007

Source: http://www.cdio.org/about

Philippine Technological Council Certification and Accreditation

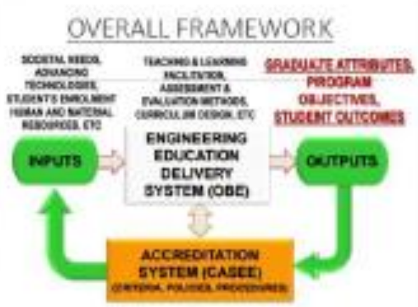
- The Philippine Technological Council (PTC) was formed in 1978 as one of the sectoral components of the Federation of Professional Associations (FPA now known as PFPA) and was incorporated in 1980 as non-stock and non-profit corporation under the Securities and Exchange Commission (SEC) by a group of concerned and selfless individuals

Philippine Technological Council Certification and Accreditation

Philippine Technological Council (PTC)

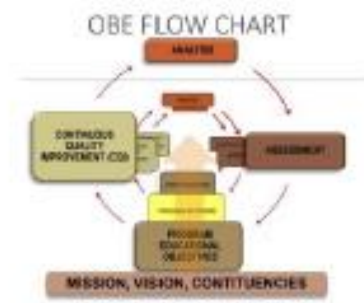
- PTC is the umbrella organization of professional engineering societies in the Philippines
- It has developed a Certification and Accreditation System for Engineering Education (CASEE)
- It is the sole body recognized by the Commission on Higher Education (CHED) to certify and accredit engineering programs offered by Higher Educational Institutions (HEIs) in the country in accordance with WA.

Philippine Technological Council Certification and Accreditation



Source:wfeo.org/wp-content/uploads/stc-technology/IFEC-CAST

Philippine Technological Council Certification and Accreditation



Source:wfeo.org/wp-content/uploads/stc-technology/IFEC-CAST

Philippine Technological Council Certification and Accreditation

ACCREDITATION CRITERIA

9 GENERAL CRITERIA:

1. PROGRAM EDUCATIONAL OBJECTIVES
2. STUDENT OUTCOMES
3. STUDENTS
4. FACULTY AND SUPPORT STAFF
5. CURRICULUM
6. FACILITIES AND LEARNING ENVIRONMENT
7. LEADERSHIP AND INSTITUTIONAL SUPPORT
8. EXTENSION SERVICE, COMMUNITY ORIENTED PROGRAMS AND INDUSTRY ACADEME LINKAGE
9. CONTINUOUS QUALITY IMPROVEMENT

SPECIFIC PROGRAM CRITERIA:

- CURRICULUM
- FACULTY

Source:wfeo.org/wp-content/uploads/stc-technology/IFEC-CAST

Reimagining and Rethinking Engineering Education


At its heart
ENGINEERING
is about using science to find
CREATIVE
practical solutions. It is a noble profession
THANK YOU!
DR. PHILIP P. ERMITA, PIE, ASEAN Eng.
Dean, College of Engineering
University of Perpetual Help System DALTA
Laguna, Philippines
philip.ermita@perpetualdalta@edu.ph

Dr. Eldho T.I

Professor & Head

Department of Civil Engineering, IIT Bombay

Professor & Head Mumbai 400076.

BIOGRAPHY

Dr Eldho is an Institute Chair Professor & Head of Department of Civil Engineering, IIT Bombay. He has 28 years of experience in the area of water resources and environmental engineering as Scientist, Professor and Consultant. He works in the areas of Fluid Mechanics, Coastal Hydrodynamics and Climate Change Impact on Water Resources, CFD, Groundwater Flow and Contaminant transport. He has guided 32 Ph.Ds, 4 Postdoctoral Fellows and 55 Masters theses and presently guiding 10 more Ph.D students in various areas. He has published more than 500 research papers in various International Journals and Conferences. He has developed and offered 25 courses and number of short term courses for college teachers and working professionals. He has also developed two popular video courses on “Fluid Mechanics” and “Watershed Management”. Prof.Eldho serves as an Editor/ Associate Editor and Editorial Board Member of a number of Indian and International Journals and has worked as a reviewer for more than 50 national and international Journals in the recent past. He is also a research proposal reviewer for many research organizations and delivered several invited/ keynote lectures at various national and international organizations and conferences. Dr. Eldho has co-authored two popular text books and contributed 15 book chapters in various edited books. He is recipient of many prestigious awards including Eminent Water Resources Scientist, constituted by Indian Water Resources Society in 2018.

MESSAGE

I am very delighted to know that K.D.K. College of Engineering Nagpur is organizing the International Conference on Advancements and Innovations in Civil Engineering (IC-AICE) during 18-20 March 2021. In the last few decades, number of innovations have happened in the area of Civil Engineering. With the advances in computer and information technologies, most of the Civil Engineering designs and executions are happening with the help of these technologies. I am happy to know that in this conference, all important areas of Civil Engineering field are covered and number of advanced research topics are deliberated. I am also happy to note that number of International organizations are sponsoring the Conference. It was very pleasing for me to know about some of the most well-known and influential voices in the field being hosted in the conference and a workout of such will be good enough for the society to be self-sufficient in any kinds of Civil Engineering works. I hereby bid all my good wishes for the IC-AICE – International Conference to achieve its grand success.

Prof. Eldho T.I

Urban Flood Management for Sustainable Development

Dr. Eldho T. I.
Professor & Head, Department of Civil Engineering,
Indian Institute of Technology (IIT) Bombay, Mumbai 400 076
(E-mail: eldho@civil.iitb.ac.in)

Urban flooding is major problem and one of the major catastrophe happening every year. The flooding can be due to heavy rainfall or coupled with high tides, especially in coastal cities all over the world. Increase in urbanization leads to higher impervious areas and correspondingly with high intensity and long duration rainfall leads to larger peaks and reduced time to peak in flood hydrograph, causing severe flooding in the urban areas. Especially, coastal urban areas are more vulnerable to flooding under combined influence of heavy rainfall and high tides. For the effective coastal urban flood management, we need to understand the flooding phenomena in a particular region due to various influencing factors such as topographic conditions, climatic factors and tidal influence, through simulation and predictions (Kularni et al., 2014a). Hence, there is a need of hydraulic flood model capable of incorporating the various components such as overland flow, channel flow, tidal condition and holding pond effects in the considered area. Due to the complexity of the problem, an integrated approach of numerical modelling coupled with geo spatial techniques of Remote Sensing (RS) and Geographic Information System (GIS) is required for appropriate flood assessment and remedial measures (Kularni et al., 2013). In this paper, various aspects of urban flooding issues especially in coastal regions, theoretical developments and modeling are discussed. The available standard models for coastal flood simulation are briefly discussed. Further an integrated approach of flood assessment in coastal urban areas using numerical models and geo-spatial techniques is illustrated.

The detailed description and applications of simulation model viz. Integrated Flood Assessment Modelling (IFAM) tool is given in Kulkarni et al., 2013, 2014. The IFAM use numerical methods in the solution of the governing equations for the rainfall runoff simulation. Remote sensing technology is used for data such as land use land cover and digital elevation model while GIS has been used for the database. Overland flow is modeled by mass balance based approach. Channel flow is modeled using diffusion wave equation solved by Finite Element Method. GIS has been used to prepare finite element grid map and input files such as Manning's roughness and slope used in the model for the watershed. LU/LC of the watershed has been derived from remotely sensed data. The methodology of the model is shown in Figure 1.

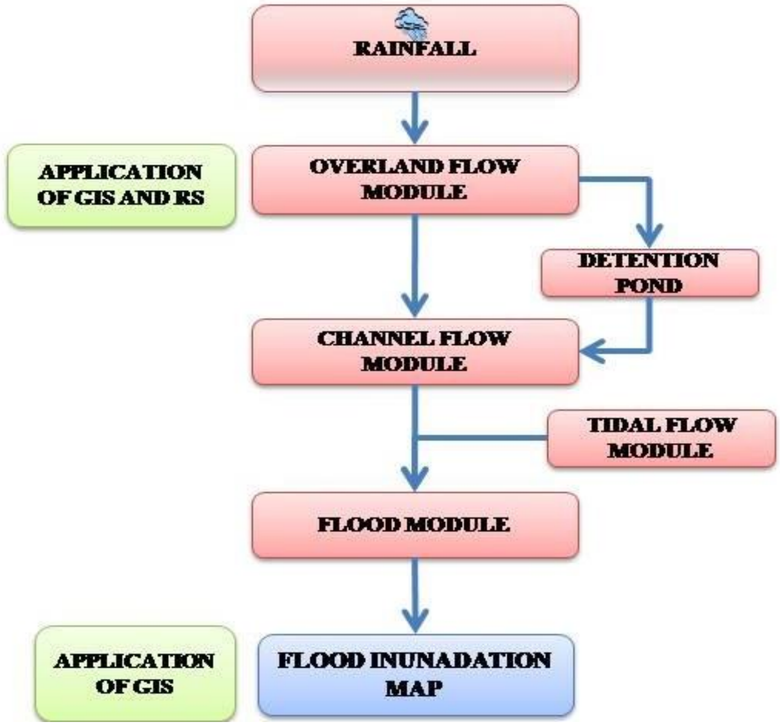


Figure 1: A Typical Urban Flood Model (Kulkarni et al., 2013)

Further the IFAM model is integrated within web GIS server. The web GIS server has been built using Java, Java Servlet Page, JQuery, HTML and XML technologies while the associated hydrological model has been built in MATLAB language and both are stored on the server side. The data input to the model is from the client-side through web browser. The model is capable of simulation 1D overland flow using mass balance approach, 1D diffusion wave based channel flow model and quasi 2D raster based floodplain model. The three main outputs (Fig. 1) from the tool (Kulkarni et al., 2014b) are a) generation discharge and stage hydrographs at any point along the channel; b) Water level profile plot at any hour of the simulation and c) Flood map animation in case of flooding in channel (Figure 2)

The IFAM model and web GIS based system are applied for number of urban catchments and checked for its effectiveness (Kulkarni et al., 2013; 2014a; 2014b). In the paper, the flood assessments of coastal urban regions in Mumbai region is demonstrated using a case study with integrated approach of numerical simulation and GIS for flood assessment and management. Figure 3 shows the typical output from IFAM model.

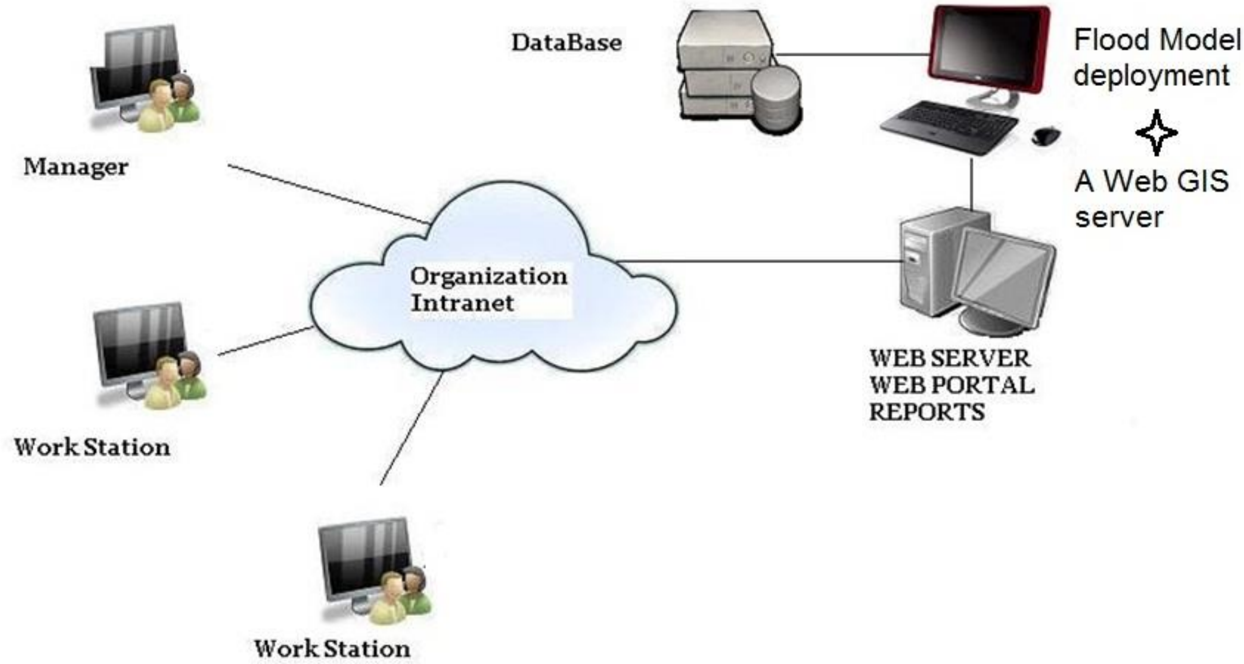


Figure 2: Typical IFAM model for urban flood management (Kulkarni et al., 2014)

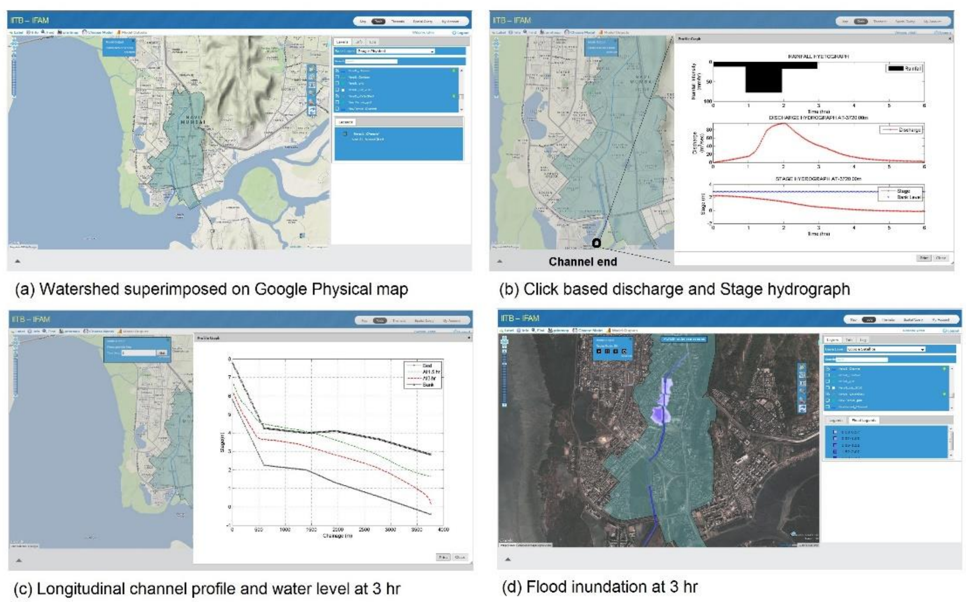


Figure 1. IFAM tool output for a typical catchment for rainfall with 10 year return period

The developed model has been found to be very useful for flood prediction in coastal urban catchment. The model can be deployed in any urban coastal cities for flood prediction or design, development and planning.

Keywords: Urban flood management, Hydrological modelling, Numerical simulation, geo-spatial technologies, Web GIS.

Acknowledgments
Authors would also like to thank Department of Science and Technology (DST), Government of India for sponsoring 09DST033 project.

References:

Kulkarni, A.T., Eldho, T.I., Rao E.P., Mohan, B.K. (2013). An Integrated flood simulation model for a coastal urban catchment of Navi Mumbai: A case study. In: *Proc. HYDRO 2013 Iinternational*, December 4-6, 2013, IIT Madras, India.

Kulkarni, AT, Bodke, S. S., Rao, E. P., and Eldho, T. I. (2014). Hydrological Impact on change in land use/land cover in an urbanizing catchment of Mumbai: a case study. Indian Society of hydraulics (*ISH) Journal of Hydraulic Engineering*, 20 (3), 314-323.

Kulkarni, A.T., Eldho, T.I., Rao, E.P., and Mohan B.K. (2014 a). An integrated flood inundation model for simulating heavy rainfall event of coastal urban watershed in Navi Mumbai, India. *Natural Hazards*, 73, 403-425.

Kulkarni, A.T., Eldho, T.I., Rao, E.P., and Mohan B.K. (2014 b). A web GIS based Integrated Flood Assessment Modeling Tool for Coastal Urban Watersheds. *Computers and Geosciences*, 64, 7-14.

Carlos Hellaman Moreira Vela

Sophomore year in General Studies

CEO, Master Degrees Monterrey, Mexico

State University of New York

Education

- Civil Engineer | Universidad Regiomontana | Monterrey, Nuevo Leon; Mexico 1995
- Masters degree in Structure Engineering | Universidad Autonoma de Nuevo Leon 2004
- Masters degree in Environmental Science | Universidad Autonoma de Nuevo Leon 2007
- Certified Geomembrane lining installation | Burr Ridge, Illinois USA 1999
- Certified in pipe ramming and pipe bursting | Aurora, Illinois USA 1996
- Certified CCTV pipe inspector | Glendale, CA USA 1999
- Member of American Concrete Institute ACI | 2008
    - Chairman for ACI committee 346 CIPCP | 2012
    - An active member of translation of ACI technical documents. | 2015
    - Associate member for Committee 304 | 2015
- Member of IMCYC 1999
- Currently sophomore year | General Studies | Brigham Young University

Professional Experience

Field supervisor | Move y Asociados SA de CV | 1995-2007

- Trenchless underground utility installations with the experience of over 9000 km of PE pipe for sewer rehab in diameters that range from 4” up to 36”, Steel pipe ramming in diameters of 8” up to 60”.
- Installed over 120,000 sq. km of PE liner on landfills and water reservoirs.

CEO for Hidraulica Ambiental 2008 - present.

- Actively an external consultant for hydraulic solutions with the state government of Coahuila.
- I have been involved in the construction of tunnels with the use of TBMs for stormwater for the Zarape Project.
- Managed the construction of over 25,000 km cast-in-place-concrete-pipes with diameters from 36” up to 160”.

Cast-In-Place Concrete Pipe

India Office:
101 Basant Niwas, Malviya Road,
Vile Parle-E, Mumbai 400057.
Email: Email: [illegible]@hotmail.com
Contact: +91 9820084909

México Office:
Carlos Moreira, CEO
Hidráulica Ambiental, SA de CV
March 10, 2021

1 What is CIPCP
  -Background
2 Why CIPCP
3 Cases of study on single and double stage
  -Hesperia CA
  -Felipe J. Mery Channel
  -Ojo de Agua an urban stream

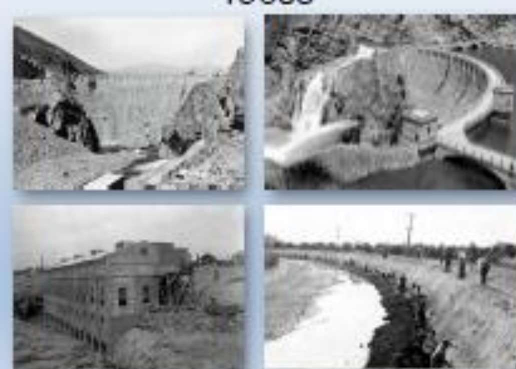
Basic Rules for Hydrology

Deaf, dumb, mute, have no handles and in large quantities they are very dangerous

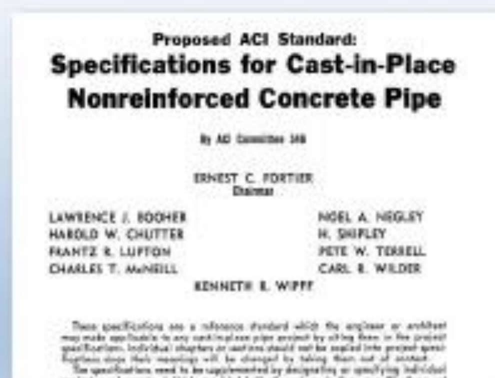
Salt Lake City, Utah, USA
1905
Diameter 2.10m (82")

Rebar equivalent to #2.6

Salt River Project
1960s



Cast-in-place concrete pipe
Arizona, USA. 1963



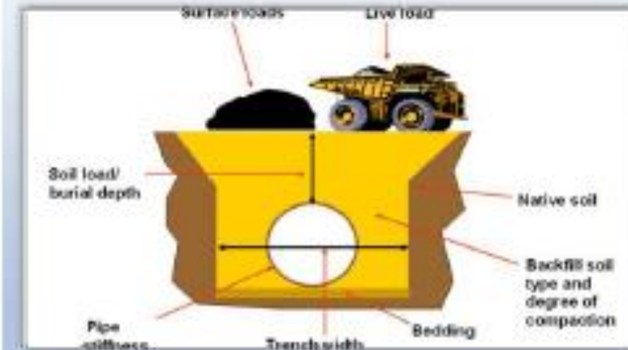
Proposed ACI Standard:

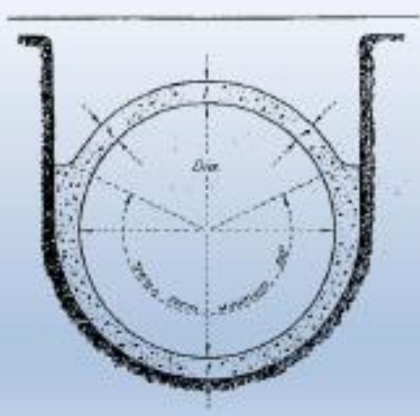
Specifications for Cast-in-Place Nonreinforced Concrete Pipe

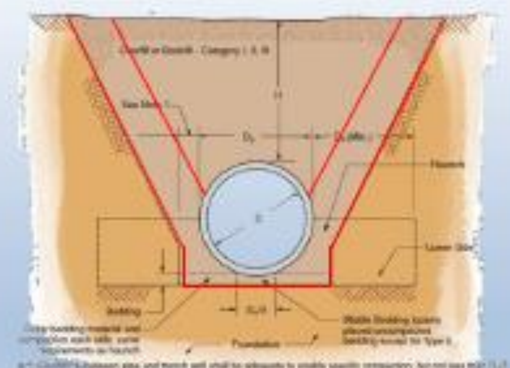
ERNEST C. FORTIER
Chairman

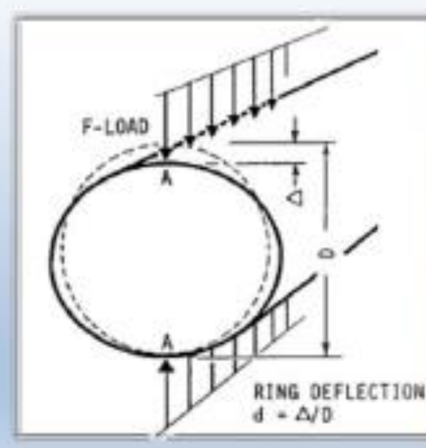
LAWRENCE J. BOOHER
HAROLD W. CHUTTER
FRANTZ R. LUFTON
CHARLES T. McNEILL
NOEL A. NEGLEY
H. SHIPLEY
PETE W. TERRELL
CARL R. WILDER
KENNETH R. WIPFF

Monterrey, NL, Mexico
1969



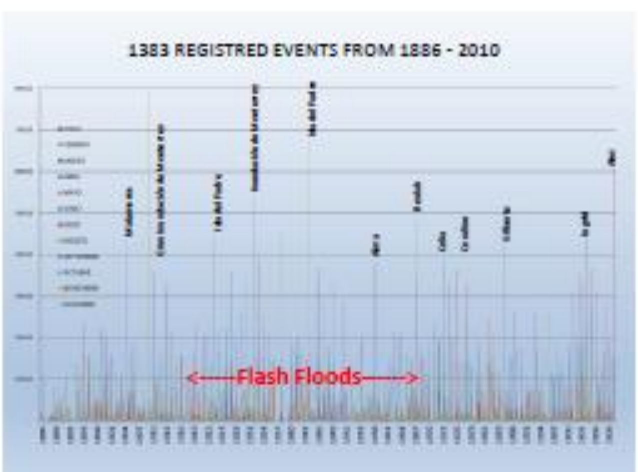


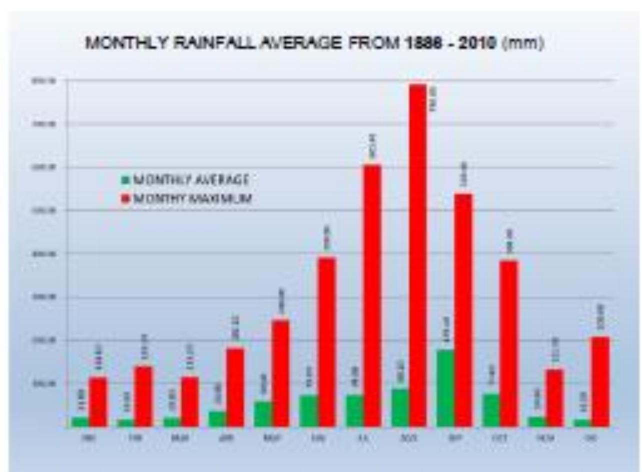





LOW CLEARAN


DILUVIA EN MONTERREY,
PERO DESABASTO SIGUE


1383 REGISTRED EVENTS FROM 1886 - 2010
<-----Flash Floods----->

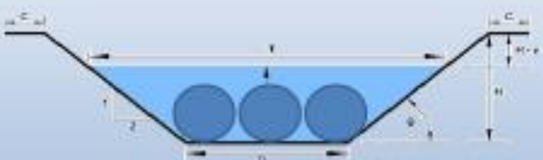

MONTHLY RAINFALL AVERAGE FROM 1886 - 2010 (mm)
MONTHLY AVERAGE
MONTHY MAXIMUM

Single Stage

2.10m-83in diameter
double barrel
Hesperia, CA, USA
2006

Double Stage

J Mery Channel
3.50m – 138in diameter
Saltillo, Coahuila, Mexico
2008



Two Budgets

A – $2,900USD/meter
B - $1,140USD/ meter

Final Cost
$550USD/meter

3.50m de diameter pipe

Concrete mix used

200 Kg/cm2 (200MPa)

No rebar, additives, fiber or ash

This size pipe has 4.20m OD, in the case of precast concrete pipe the minimum trench needed has to be 5.60m wide

Double Stage

Ojo de Agua an urban stream
Saltillo, Coahuila, Mexico
2011


Coahuila
2010/03/12

Roadheader

SC Concrete 200 Kg/cm2
No fiber or ash

Thank you

Ing Carlos Moreira

Mahdi O. Karkush, Ph.D., CE, MISSMGE

Dean, College of Engineering

University of Pepretual Help System DALTA

Calamba City, Laguna, Philippines

Fellow, Institute for Engineering Research and

Publication

PRESENT EMPLOYMENT
Faculty**,** College of Engineering, University of Baghdad, Al- Jadiriah, Baghdad- Iraq
Main Responsibilities

- Member of Civil Engineering Department board.
- Teaching postgraduate courses in Civil Engineering Department (MSc).
- Teaching undergraduate courses in Civil Engineering Department.
- Supervising final year projects.
- Supervising MSc & PhD theses.

Education :
PhD

- (83.85 %) Geotechnical Engineering University of Baghdad, College of Engineering, Civil Engineering Department

***PhD study included two courses and comprehensive exam:**

1. Advanced Soil Mechanics-I, Seepage, Soil Improvement, and Soil Dynamics.
2. Advanced Soil Mechanics-II, Earth Structures, Advanced Foundation Design, and Constitutive Relationships.
3. The comprehensive Exam including written and oral exam in the following subjects:
4. Advanced Soil Mechanics, Soil Dynamics, Seepage, Earth Structures, Advanced Foundation Design,Soil Improvement, Advanced Concrete Technology, Constitutive Relationships, and Finite Element.

TEACHING AT THE UNIVERSITY OF BAGHDAD
Undergraduate

1. Soil Mechanics.
2. Mathematics-I.
3. Mathematics-II.
4. Foundation Engineering.

Graduate

MSc level

1. Advanced Soil Mechanics-I,
2. Advanced Soil Mechanics-II,
3. Seepage in Soils
4. Advanced Laboratory and Field Soil Testing.
5. Geoenvironmental Engineering

PhD level

1. Geoenvironmental Engineering,
2. Geomatic Engineering,
3. Soil Dynamics,
4. Sustainability in Geotechnical Engineering

Thesis Supervision

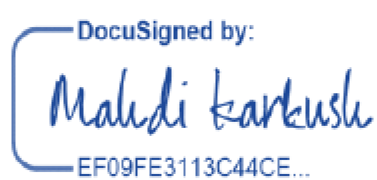
(MSc and PhD levels)

1. Studying the Effects of Some Contaminants on the Geotechnical Soil Properties by Testing andRemote Sensing/MSc Thesis.
2. Investigation the Effects of Contamination and Washing Process on the Geotechnical Propertiesof Sandy Soil/MSc Thesis.
3. Effect of Soil Contamination on the Behavior of Piles Subjected to Laterally Cyclic Loading/MScThesis.
4. Effects of Embankment Construction nearby an Axially Loaded Pile(s) /MSc Thesis.
5. Studying the Contamination and Remediation of Al-Nassyria Oil Refinery Soil/MSc Thesis.
6. Theoretical Analysis and Experimental Modeling of Surcharge Adjacent to Pile Foundation inContaminated Soils/MSc Thesis.
7. Geotechnical Properties and Electrokinetics Remediation of Heavy Metals Contaminated Soil/MSc Thesis.
8. Remediation of Contaminated Soil Under Foundation Subjected to Static and Cyclic Loading/PhD Thesis.
9. Consolidation Modeling of Kerosene Contaminated Clayey Soils/MSc Thesis.
10. Behavior of Floating Stone Columns in Weak Soil Under Static and Cyclic Loading/MSc Thesis.
11. Environmentally Sustainable Use of Recycled Crushed Concrete in Soil Improvement/MSc Thesis.
12. Improvement the Geotechnical Properties of Soft Soil Using Microbial Induced Calcite Precipitation Enhanced with Electrokinetics Technique/PhD Thesis.
13. Behavior of screw piles under static and cyclic loading in gypseous soils/PhD Thesis.
14. Impacts of Microbial Induced Calcite and Nano Materials on the Compressibility of GypseousSoils/PhD Thesis.
15. Impacts of Magnetic Water Treatment on The Behavior of Screw Piles in Expansive Soil/PhDThesis.
16. Investigation the Performance of Screw Piles in Soft Soil Under Axial Static and Cyclic Loadings/MSc Thesis.

MESSAGE

I am really proud to be part of "International Conference on "Advancements and Innovations in Civil Engineering" (IC-AICE-2021)" organized by K.D.K.College of Engineering, Nagpur in Association with Institute For Engineering Research and Publication (IFERP). The contiuos cooperation between researches, academics, and construction industrials will produce more sustainable world. I really appreciate the efforts of research who submitted papers in this conference and wish succeful and progressing for the orgainzers of this event during the period of covid-19 pandameic. I am eager to discover the Advancements and Innovations in Civil Engineering achieved by researchers and academics.

I would like to extend my thanks to all participants who have joined (IC-AICE-2021) conferece to make our future better with disruptive ideas.



Mahdi O. Karkush

SUSTAINABILITY ASPECTS AND DEEP REMEDIATION OF CONTAMINATED SITES

Mahdi O. Karkush[1] and Mahmoud S. Abdul Kareem[2]

[1]Professor of Civil Engineering, University of Baghdad; Baghdad, Iraq

[2]Ph.D., Senior Engineer, Babylon Governorate, Babylon, Iraq.

ABSTRACT

The objective of this study is to apply the concepts of sustainability in geotechnical engineering by introducing a simple and practical framework. Also, the suggested framework will be used to evaluate the efficiency of using natural materials such as lime piles in remediation and improvement of the geotechnical properties of contaminated clayey soil. Reducing the carbon dioxide emissions from the construction industry and remediation of contaminated sites using environmentally friendly techniques acquired global attention. In the suggested framework both approaches of quantitative and qualitative can be used in the evaluation of geotechnical projects. Several indicators will be used in the evaluation of sustainability pillars: natural resource, social impacts, environmental, and economic aspects. A case study was evaluated using Multi-Criteria Analysis and Life Cycle Analysis to provide a comprehensive image of the sustainability of geotechnical projects, in total and/or individually. Three scenarios have been suggested to design the foundation of a building of dimensions 50×50 m in contaminated clayey soil. Then, these three scenarios were analyzed depending on the suggested framework and the results of analyses showed that using lime piles in the remediation and improvement of the geotechnical properties of contaminated soil is considered more sustainable than using soil replacement or pile foundation.

K. N. GUNALAN, Ph.D., P.E., F.ASCE, D.GE

2020 President of American Society of Civil Engineers

West Jordan, Utah, United States

State University of New York

BIOGRAPHY

K.N. Gunalan (Guna) is Senior Vice President of transportation Alternative Delivery, Americas at AECOM, based in Salt Lake City, UT. Previously, he was a Vice President at Parsons Brinckerhoff (WSP).

Guna has managed large complex infrastructure projects, providing technical advice on civil, structural, geotechnical, pavement, and materials issues on a variety of projects around the world. His collaborative approach has contributed to many successful programs and projects ranging from a few thousand dollars to more than 3 billion dollars.

He has been active in ASCE for many years, including leadership roles as Region 8 director (2009-2012), Region 8 governor (2005-2007), Utah Section president (2002-2003), and Texas Section High Plains Branch president (1992). He served as the chair of ASCE's 2014 Global Engineering Conference in Panama City, Panama, in celebration of the 100th anniversary of the Panama Canal. Most recently, he served as a governor for the Geo-Institute and was a member of the steering committee for the 2017 ASCE India Conference.

Guna has been married for 38 years to Duru. They have a son, Kabilar, and a daughter, Pallavi. He loves to read, travel, and learn about new cultures.

MESSAGE

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Plains Branch president (1992). He served as the chair of ASCE's 2014 Global Engineering Conference in Panama City, Panama, in celebration of the 100th anniversary of the Panama Canal. Most recently, he served as a governor for the Geo-Institute and was a member of the steering committee for the 2017 ASCE India Conference.

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K. N. GUNALAN

International Conference on Advancements and Innovations in Civil Engineering Addressing Climate Crisis

Dr. K.N. Gunalan

2020 President of American Society of Civil Engineers, West Jordan, Utah, United States

Civil Engineering profession and the construction industry has witnessed dramatic growth in the last 50 years. Graduating from the oldest civil engineering program at College of Engineering, Guindy, Chennai that started as the Survey School of India under the British some 225 years ago. I had to take surveying classes over three years starting with chain and tape and finishing with a survey camp that involved using the Theodolite along with 10 figure log tables to close out the survey. Now we use lasers, LiDAR, GPS to measure and stake boundaries and alignments. Also went from drafting table to MicroStation to BIM. However, the basic engineering principles that we learned then, remain true and will do so for foreseeable future. We have landed on Mars and are gathering images to see if we find evidence of ancient life! We have seen several advances and innovations in tools and technology that we use today such as Artificial Intelligence, robots, drones etc. We have seen advances in material materials from concrete to self-healing concrete; steel to graphite; fiber to nano materials, glass to bio repellant surfaces. We all are very fortunate to be alive during this time to have witnessed the dramatic changes which we hope has and will continue to enhance our quality of life on this planet. Tools and technology have made it possible for us as civil engineers to compute, analyze, engineer and design the built environment. We can engineer and build large, complex structures at a much rapid pace than that would have been possible even a few decades ago. Does that mean we are doing better? Yes maybe! But if these are not built with care for the quality and pride of aesthetic value, they will not last long enough to serve the intended purpose leave alone to stand as testament to our ingenuity and capabilities. It takes a village to build the large, complex infrastructure and we need to make sure that everyone involved including the unskilled labor is made aware of the details of why and how to build these structures to garner ownership and pride in every step of the process by engaging.

Advances and innovation will have no meaning if it only serves a few. We need to not only continue to think out of the box but also make sure that they benefit humanity at large. We have a responsibility to make sure that the infrastructure that we build is not only sustainable, but it is resilient. As we are looking to make advances and innovate, need to make sure that we do not contribute to climate change. As we know now, manufacturing of construction materials such as cement, steel etc. contributes to global warming. So as we look to addressing the challenges of housing, energy, clean water, disposal of waste, mobility etc. associated with population growth in the coming years, we need to think of solutions that do not contribute to adverse weather events resulting from climate change. Civil engineers can and should play a key role in achieving the United Nations (UN) Sustainable Development Goals (SDG's) by 2030. It is said the innovation and technology is going to be the key to solving the climate crisis. Let us do our part to make sure that we are not only not contributing to but are finding solutions to mitigate climate crisis while providing the infrastructure needed to enhance the quality of life.

RONALD L. ORALE, Ph.D

Program Head, Master of Engineering Program

& Vice President for Research & Extension

Samar State University

BIOGRAPHY

Dr. Ronald Orale working as an Professor VI in Samar State University, Philippines and Vice President for Planning Research and Extension. He was awarded Loyalty Service Award for 20 Years in Service. He is an active member of Phil. Institute of Civil Engineers (PICE), Geodetic Engineers of the Philippines (GEP), Samar State University Personnel Association, National Civil Engineering Educators in the Philippines (NCEEP), Philippine Association for Graduate Education. Philippine Society for the Study of Nature (PSSN), Inc Philippine Association of Research Managers. Also, he is Consultant in MPEX Consultant for Industry sector in Samar. He also served in Advisory and Technical committee conference and given a Keynote talk in various National and international conference. He is also awarded with the Best paper award in many international conferences and expertise in Civil Department.

MESSAGE

Mabuhay!!!

I am very pleased to have been included in the list of keynote speakers in the upcoming International Conference on “Advancements and Innovations in Civil Engineering” organized by KDK College of Engineering, Nagpur. While the conference focus is along with the latest discoveries in the field of civil engineering, I would like to focus on the need for multi-disciplinary and inter-disciplinary approaches in addressing issues of the communities, especially the impact of climate change. While some of the previous fields under the civil engineering (CE) profession have part ways; societal problems have become more complex making it difficult to be addressed by CE alone. More than ever, problems in society require various disciplines to effectively address them.

In recent years, I saw water-related issues as one of the most important resources that need to be given much attention. Water (too much of it or without it) is a vital resource that communities cannot afford to lose. While some areas may have experienced more water which causes floods, some don’t have it. It has been proven that everything that we do has an impact on climate change, what we can do is to ensure that we do not contribute much to it. Trying to address the impact of climate change is a double-edged sword that when not properly studied will result in another disaster. Our tasks as engineers are to reduce the negative effects of everything that we do to our environment. Engineers are not called “the masters of the laws of nature” for nothing.

Solving issues along climate change is a multi-disciplinary and inter-disciplinary task, no single profession can claim expertise in it. I will try to share my current research along with water resources engineering as I apply it to my hometown, the City of Catbalogan, the Philippines. Advances in the field of civil engineering for me do not mean top-of-the-world/state-of-the-art engineering approaches. In the developing world where resources are scarce, even the most traditional approaches are worthy enough to be used to mitigate the impact of climate change--at least until the more advanced engineering discoveries/technologies are made available to them. One thing I’m sure is important, knowledge/information are key to addressing climate change-related issues.

While I may be one of your keynote speakers, I am equally excited to hear from other speakers and sharing of the participants of this conference as well. We are all experts in the fields where we are in, I consider everyone as a valuable partner in looking for solutions to the problems of society. I am very eager to learn from everyone who attends this conference. I hope too to be partners with you in looking for solutions to problems besetting our communities; especially solutions that belong to the field of Civil Engineering.

Mabuhay(Long Live) to all who heed the call to participate this conference

RONALD L. ORALE

Water-Related Challenges of Cities in Developing Countries

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Abstract— Water scarcity and oversupply of water are two contrasting water-related issues faced by communities all over the world. The paper explored recent literature to learn various water-related problems that cities are facing. The narrative literature generated four themes; water scarcity, urban runoff, water contamination, floods, and sustainable cities. There are a lack and oversupply of water. Water is scarce due to higher demand and the continued reduction of available water for extraction due to erratic climate and contamination of available sources. The oversupply of water is because of the beyond regular precipitation rate. To be adaptive to the forecasted risks, cities need to plan approaches to make use of the negative impact of climate change as an opportunity to address the water scarcity issues that cities in the developing countries are facing. Everyone in the community and the vital role of political leaders in making their cities more sustainable is paramount. Options presented to address water-related issues require intensive fact-based planning and decision making by the stakeholders and leaders. There is also an urgent need for immediate and sustained implementation of the intervention as its impact will be felt decades after.

Index Terms— oversupply of water, stormwater harvesting, water scarcity, water security

Dr. Mohammed Alias Yusof

Associate Professor

National Defence University Malaysia

MESSAGE

K I am really honored to be part of "International Conference on "Advancements and Innovations in Civil Engineering" (IC-AICE-2021)" organized by K.D.K.College of Engineering, Nagpur in Association with Institute For Engineering Research and Publication (IFERP). Today we can not imagine life without having advancement in innovation of civil engineering and it has become integral part of our life. Such conference gives opportunity to bring those hidded ideas on the table. I really appreciate your effort on publishing papers. My message to all participants is to carry out more research and development in the area of on Advancements and Innovations in Civil Engineering

I would like to extend my thanks to all participants who have joined (IC-AICE-2021) conferece to make our future better with disruptive ideas.

Dr. Mohammed Alias Yusof

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Study of Modified Bolomey’s Equation for Concrete Made with Partial Use of Coal Bottom

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Abstract

Many researchers are working to predict strength of concrete to compare it with experimental results. When blended cement is used to prepare concrete then it gets more difficult and challenging for predicting the compressive strength of concrete. Bolomey’s equation is one of the methods to determine the compressive strength. In this work Bolomey’s modified equation has been used to predict strengthas Coal bottom ash has been used as a partial replacement of cement in concrete production. The predicted results are compared with the experimental data of test where the high R-square value indicates the accuracy of the experimental data and also an equation is suggested to predict compressive strength in future. This work is very helpful for those who have a good set of experimental data and need to verify and predict the compressive strength of concrete. This work enhances the importance of use of statistical analysis in research related to concrete production.

Keywords

Replacement, Coal bottom ash, Bolomey’s equation, Prediction, Compressive strength

Introduction

In India natural resources are depleting day by day and at the same time Industrial wastes is creating problem for the environment due to its disposal. For a green, durable and sustainable concrete structures, supplementary cementitious material (SCM) need to be introducedto improve the strength and durability of concrete. There are many industrial wastes which are nowadays reused or recycled to reduce this environmental impact. One such industrial waste is coal bottom ash generated as a waste from Coal Power Plants. Coal Bottom ash has a high potential to be used as a pozzolanic material in concrete. CBA occupies more area of land and cement production emitted CO_2 emissions in environment but provides great opportunity to be developed as cementitous material. Hence an effort is being done to utilize coal bottom ash (CBA) as a partial substitution of cement while making concrete. To evaluate the utility of such waste the compressive strength of concrete is to be tested and the results should be satisfactory to suggest the use of the waste in concrete production. Other than durability of concrete consumers normally ask for target strength of concrete. The different ways of achieving target strength is either by increasing cement, use of supplementary cementitous material, reducing amount of water as curing conditions can greatly affect the water absorption of concrete or by use of a superplasticizer. Hence researches have studied to propose many formulas to calculate strength of concrete. Researches that used Bolomey’s formula found that for same quality of cement paste compressive strength differs when crushed aggregates are used instead of natural aggregates. Some formulas calculate the strength of concrete by only considering the w/c ratio based on the Abrahm’s Law. However even if same w/c ratio is used for two different mixes still the compressive strength of both concrete will be different if the cement content varies for both. Also many formulas fail to consider the strength class of cement as again strength varies for different classes of cement. Majority of the people used Feret and Abrams formula to calculate the strength of concrete. A research also proposed a modification of Bolomey’s formula by taking into consideration the w/c ratio, the class of cement and the method by which the aggregates are produced. Hence Bolomey’s modified equation was used to analyze the test results.

Methodology

Strength prediction is an important aspect for ready mix concrete. The compressive strength of concrete at any particular age t days mainly depends on cement type, temperature and curing. To predict strength under normal curing condition there are many empirical formulas to predict the strength of concrete and researchers found Abram and Bolomey as the more famous founders of the theories to predict strength.

Following are the Abram and Bolomey's equation

$$fc = \left(\frac{A}{B}\right)^{w/c} \tag{1.1}$$

$$fc\,(t) = k_1\,(C/W) + k_2 \tag{1.2}$$

In above formula of Abrams equation fc is compressive strength of concrete, A and Bare the constants and w/c is the water to cement ratio. In Bolomey's equation, fc(t) isthe compressive strength of concrete at (t) days, c is the quantityof cement, W is the water quantity; k1 and k2 are theconstants.

This study compared the results of strength of concrete of grade M20 obtained by replacing cement with CBA at 0.4 and 0.5 w/c ratio respectively to the strength predicted by use of modified Bolomey's equation. Since CBA has been used as a SCM hence the Bolomey's modified equation (BME) for the concrete containing SCM like CBA as a partial cement replacement and following equation is used.

$$fc\,(t) = A(t)\left[\frac{\alpha(CBA + PC)}{W}\right] + \beta \tag{1.8}$$

$$A(t) = \frac{t}{a + bt} \tag{1.9}$$

Where; A(t) is the function of age, C is quantity of cement(kg/m3), CBA is quantity of coal bottom ash (kg/m^3), PC isthe quantity of Portland cement (kg/m^3),Wis the water quantity(kg/m^3), α, β, a and b are the constants and a and b were considered as 3.5 and 0.80 as it can be called as blended cement.
α represents theefficiency of CBA, In this study concrete was kept in immersed curing conditions, thus 3.5 value for β parameterhas been fixed for all conditions.
The experimental compressive strength of concrete is taken as the mean average of three specimens. However, the proposed predicted equationvalues were compared with the average results of concrete.

Results and Discussion

The results obtained through Bolomey's modified equation(BME) were compared with the experimental compressive strength and tabulated in Table No.1 below

Table 1 Comparison of predicted strength and actual strength

A(t)	t	CBA	PC	W	a	b	α	β	Fc(t)	Experimental Fc	% Difference
1.007	28	0	440	169.7	4	0.85	7	3.5	21.81	22.43	2.770921712
0.769	7	22	418	169.7	3.5	0.8	7	3.5	16.66	14.82	-12.38818326
1.034	21	22	418	169.7	3.5	0.8	7	3.5	22.4	21.4	-4.669871351
1.081	28	22	418	169.7	3.5	0.8	7	3.5	23.41	23.8	1.645662563
0.769	7	44	396	160.7	3.5	0.8	7	3.5	17.43	15.2	-14.68214135
1.034	21	44	396	160.7	3.5	0.8	7	3.5	23.44	23	-1.924397888
1.081	28	44	396	160.7	3.5	0.8	7	3.5	24.5	24.61	0.452722446
0.769	7	66	374	151.8	3.5	0.8	7	3.5	18.298708	15.45	-18.43823759

1.034	21	66	374	151.8	3.5	0.8	7	3.5	24.608607	19.23	-27.96987477
1.081	28	66	374	151.8	3.5	0.8	7	3.5	25.717103	21.2	-21.30708832
0.769	7	17.6	334.4	169.4	3.5	0.8	7	3.5	13.878411	12.24	-13.38571012
1.034	21	17.6	334.4	169.4	3.5	0.8	7	3.5	18.66407	19.41	3.843019806
1.081	28	17.6	334.4	169.4	3.5	0.8	7	3.5	19.504794	20.94	6.853898171
0.769	7	35.2	316.8	160.5	3.5	0.8	7	3.5	14.499861	13.02	-11.36606066
1.034	21	35.2	316.8	160.5	3.5	0.8	7	3.5	19.499813	19.7	1.016176649
1.081	28	35.2	316.8	160.5	3.5	0.8	7	3.5	20.378183	21.13	3.558054121
0.769	7	52.8	299.2	151.6	3.5	0.8	7	3.5	15.194423	14.5	-4.78912457
1.034	21	52.8	299.2	151.6	3.5	0.8	7	3.5	20.433879	20.11	-1.610538494
1.081	28	52.8	299.2	151.6	3.5	0.8	7	3.5	21.354324	21.8	2.044383926

Above experimental results are obtained by partial replacement of cement with 5%, 10% and 15% of CBA at two different water cement ratios of 0.4 and 0.5 respectively for each percentage replacement. The experimental results are obtained from the average value of three cubes for one proportion mix.

For controlled concrete the % difference is observed as only 2.78 % which indicates that the Bolomey's equation is justified to predict the value of strength of concrete and the controlled concrete is also tested correctly. The least % difference is been observed for 28 days of concrete with 10% of CBA replacement at 0.5 w/c ratio. Higher value of % difference is seen for 15% replacement percentage of CBA at 0.4 w/c ratio whereas for same 15% replacement at 0.5 w/c ratio % difference is quite less.

Further a correlation was established between experimental results and predicted results obtained in the table above by plotting a graph between both and R^2 value was calculated for each graph.

Fig. Below shows the graph plotted.

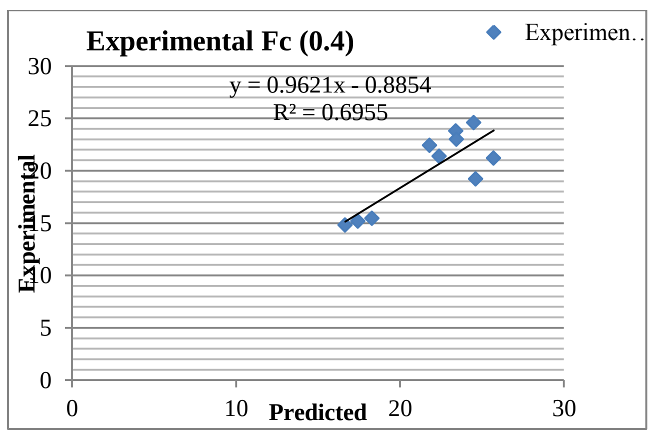

Fig. 1 Experimental strength Vs Predicted strength at 0.4 w/c ratio

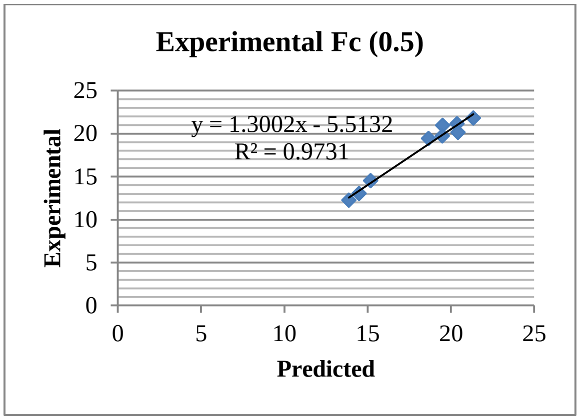

Fig. 2 Experimental strength Vs Predicted strength at 0.5 w/c ratio

In graph R^2 values indicates the total variation and the greater R^2 value indicates the good results. R^2 value for 0.5 w/c ratio is 0.9731 which indicates the precision of the test results within the confidence level. Whereas for 0.5 w/c ratio the value is quite lower which indicates either to give a thought to repeat the tests and even recheck and revise the constants used in Bolomey's equation if required.

Conclusion

- The experimental test results for 0.5 w/c ratio and replacement of 5%, 10% and 15% are found to be precise and accurate as they correspond well to the predicted results obtained by use of modified Bolomey's equation.
- The constants used in Modified Bolomey's Equation need to be again revised and some more research is required to predict the strength in future. This is specially of more importance as the cement has CBA substitution i.e. blended cement is used to prepare concrete.
- The experimental results for 0.4 w/c ratio has to be tested again taking into consideration the specific surface area of CBA and water absorption as well as they may be the reason for the difference in experimental results.
- More prediction formulae can be studied to verify experimental data of strength with more sets of experimental values and also to suggest an empirical formula to predict strength in future.

Reference

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1. Aasif Baig and Valsson Varghese, "Study of Properties of Coal Bottom Ash and Waste Foundry Sand and its Use in Concrete" Springer Nature Singapore Pte Ltd. 2019
M. L. Kolhe et al. (eds.), Smart Technologies for Energy, Environment and Sustainable Development, Lecture Notes on Multidisciplinary Industrial Engineering, https://doi.org/10.1007/978-981-13-6148-7_17
2. C. Jaturapitakkul, R. Cheerarot, Development of bottom ash as pozzolanic material, J. Mater. Civ. Eng. 15 (2003) 48–53, https://doi.org/10.1061/(asce) 0899-1561(2003) 15:1(48).
3. H. Kurama, M. Kaya, Usage of coal combustion bottom ash in concrete mixture, Constr. Build. Mater. 22 (2008) 1922–1928, https://doi.org/10.1016/j.conbuildmat.2007.07.008.
4. E. Aydin, Novel coal bottom ash waste composites for sustainable construction, Constr. Build. Mater. 124 (2016) 582–588, https://doi.org/10.1016/j.conbuildmat.2016.07.142.
5. E. Menéndez, A.M. Álvaro, M.T. Hernández, J.L. Parra, New methodology for assessing the environmental burden of cement mortars with partial replacement of coal bottom ash and fly ash, J. Environ. Manage. 133 (2014) 275–283, https://doi.org/10.1016/j.jenvman.2013.12.009.
6. Aasif M. Baig, Valsson Varghese, "COAL BOTTOM ASH AS A CONCRETEINGREDIENT: REVIEW"

 ISBN: 978-93-90214-19-8

Electronic copy available at: https://ssrn.com/abstract=3370497

7. S. Kizgut, D. Cuhadaroglu, S. Samanli, Stirred grinding of coal bottom ash to be evaluated as a cement additive, Energy Sources Part A Recover. Util. Environ. Eff. 32 (2010) 1529–1539, https://doi.org/10.1080/15567030902780378.
8. S.A. Mangi, M.H. Wan Ibrahim, N. Jamaluddin, M.F. Arshad, R. Putra Jaya, Short term effects of sulphate and chloride on the concrete containing coal bottom ash as supplementary cementitious material, Eng. Sci. Technol. Int. J. 22 (2019)515–522, https://doi.org/10.1016/j.jestch.2018.09.001.
9. Hopkins et al., Cementitious composition containing bottom ash as pozzolana and concretes and mortars Therefrom, United States Pat. 5849075 (1998).
10. Sajjad Ali Mangi1 &MohdHaziman Wan Ibrahim2 &Norwati Jamaluddin2 & Shabir Hussain Khahro3 &Shahiron Shahidan2, "Establishment of Strength Prediction Equation for Concrete Containing Coal Bottom Ash Exposed to Aggressive Environment",Accepted: 26 August 2020 # Springer Nature B.V. 2020
11. Navdeep Singh, Shehnazdeep, Anjani Bhardwaj, "Reviewing the role of coal bottom ash as an alternative of cement" Construction and Building Materials 233 (2020) 117276, https://doi.org/10.1016/j.conbuildmat.2019.117276
12. PenpichchaKhongpermgoson, et.al. "The mechanical properties and heat development behavior of highstrength concrete containing high fineness coal bottom ash as a pozzolanic binder" Construction and Building Materials 253 (2020) 119239, https://doi.org/10.1016/j.conbuildmat.2020.119239
13. C. N. Ibeto, C. J. Obiefuna, K. E. Ugwu, "Environmental effects of concretes produced from partial replacementof cement and sand with coal ash" International Journal of Environmental Science and Technology, https://doi.org/10.1007/s13762-020-02682-4
14. MohdHaziman Wan Ibrahim, Sajjad Ali Mangi, MohdIrwan Juki, "Effects of Coal Bottom Ash as Cementitious Material onCompressive Strength and Chloride Permeability of Concrete" IJSCET, VOL. 11 NO. 2 (2020) 1–12
15. Sharan Kumar Goudar and BibhutiBhusan Das, "Influence of Particle Size of Bottom Ash on Mechanical Properties of M30 GradeConcrete" Springer Nature Singapore Pte Ltd. 2021 B. B. Das et al. (eds.), Recent Trends in Civil Engineering, Lecture Notes in Civil Engineering 105, https://doi.org/10.1007/978-981-15-8293-6_44
16. Sharon Gooi, Ahmad A. Mousa, Daniel Kong, "A critical review and gap analysis on the use of coal bottom ash as asubstitute constituent in concrete" Journal of Cleaner Production 268 (2020) 121752, https://doi.org/10.1016/j.jclepro.2020.121752
17. N.R. Arun, Punit Singh, Supratic Gupta, "Utilisation of ground bottom ash in concrete" https://doi.org/10.1016/j.matpr.2020.03.155
18. NorazielaSyahiraBaco et al, "Strength Properties of Untreated Coal Bottom Ashas Cement Replacement" Journal of Civil Engineering Forum, January 2020, 6(1): 13-18
DOI 10.22146/jcef.47657
19. Zahid Hussain et al, "COAL BOTTOM ASH AS SUPPLEMENTARY CEMENTITIOUS MATERIAL INCONCRETE WITH AND WITHOUT PAPER PINS" Journal of Engineering Science and TechnologyVol. 15, No. 3 (2020) 2040 - 2050

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 ISBN: 978-93-90214-19-8

Literature Review On Dynamic Analysis of Intake Well and Foundation

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Abstract - In recent years, a lot of research has been carried out on earthquake resistant design of structures which a result into changes in the Indian seismic code IS: 1893-Part -1-2002. In this paper the dynamic behavior of intake well is studied. Intake well is a hallow RCC structure used to collect water from various sources such as river, lake, canal etc. to deliver it to further process. As intake well is linked to water supply arrangement and its failure may affect human essential in life. Therefore, it is very important to understand the behavior of such structure during the event of earthquake effect and reduces loses. The main aim of this study is to calculate the seismic forces acting on the selected intake structure as per IS: 1893 - Part 1-2002 and IS: 1893 - Part-1-2016 and also to study its dynamic behavior.

Keywords: Dynamic analysis, Earthquake resistant design, Intake well, IS: 1893 - Part 1-2002, 1893 –Part-1-2016.

1. Introduction

Generally outlet work comprise of combination of structure such as intake structure, pipe conduit, and outlet control structure. The main purpose of such structure is to control the released water from the source as required for project purposes or operation and it also used to support water supply system and to control the flood flows. In many cases, the outlet works helps to reduce the reservoir levels which ultimately minimize the extent of damage during the catastrophic failure like earthquake. For water supply system the outlet works consist of an intake well and rising main pipe, in addition to control valves, approach bridge and energy dissipaters which are necessary for operation of system. There might be more than one opening in an intake structure to offer for the valves and gates that assist to manage the flow of water and hence regulating water supply. The operation of controlling the flow of water is housed within the intake well. There are mainly two types of intake structures: free standing intake structure which is commonly constructed in water supply system. These are vertical tall structure with an approach bridge at its top and the other one is inclined type intake structure (structure supported against the abutment).

As the whole water supply system of a town or a project is depend upon the intake structure. Therefore it is very important to understand its dynamic behavior. This study mainly focus on to understand the dynamic response of the intake well during an earthquake and also to study various dynamic characteristics which considerably affect the behavior of intake well during the event of an earthquake.

2. Objectives

The objective of our work is to study the various dynamic parameters and seismic analysis of intake well. The main objective of our project is to calculate the seismic forces acting on the selected intake structure as per IS: 1893 - Part 1-2002 and IS: 1893 -20 IS: 1893-Part-1-2016. The key ideas of undertaking the present study are as follows:

- To study the various parameter for dynamic analysis.
- To carry out seismic analysis of intake well as per selected IS Code.

- To carry out dynamic analysis of intake well considering different submergence conditions, the ratio of outside radius to height of intake structure and wall thickness.

3. Methodology

The safe and efficient operation of intake well is primary aspects for the water supply work. Indeed, the failure of an intake well can have tragic consequences, as testified by numerous dam break cases that occurred in the past. In many case studies it is validated the earthquake and floods are the main causes of failure of such structure. Hence design of such structure requires innovative approaches beside traditional methods. Therefore for this, detailed literature survey is carried out in the present work to find out gaps in analysis and design process of these structures.

4. Literature review

Frank Lin, Norbert Bakkers, Michael Johnson, Yongwon Lee, Neil Southall, Zhenhong Wang, and Nigel White (2014) in this paper the author explains about the challenges in hydrodynamic analysis for structures in waves. For the structure standing in waves the Hydrodynamic analysis is one of the key factors for safety assessment. Many alternatives are available for answering challenge raised from offshore energy industry and marine structure, from uneconomical three dimensional CFD to the efficient but not perfect boundary element models. This paper main discuss on the boundary element methods, analysis methods for the interaction of waves and structures. Those boundary element models cover time domain and frequency domain, linear and non-linear. Mainly attention is given to the problems encountered in those models and approaches they adopted for their engineering solution. Based on the analysis and study the use of different methods based on linear boundary element method and other nonlinear models like CFD, viscous damping and viscous Morrison force is described in this paper and also a simplified nonlinear time domain correction method, intermittent, for design shearing force and bending moment has also been presented. From the examples given in this paper we can see the efforts for improving the efficient numerical tool to answer the requirement from the marine and offshore industry.

Kangning Dang, Yunhe Liu and Jingyi Zhang (2017) in this paper the author describes results of numerical analysis of hydropower station intake tower seismic response in step-like ground based on artificial boundary theory. A L topography finite element model was created to validate the correctness of the proposed approach of viscous elasticity boundary by consider inconsistent reflective surface. The proposed method is applied to a selected intake tower, and the acceleration of bedrock was found by seismic inversion method, after that the equivalent load of each node was calculated. The different models were established as follow: a) massless foundation, b) consistent input viscous elasticity boundary, c) inconsistent input viscous elasticity boundary and whether set contact, then stress and displacement were compared, the results show that the proposed method with contact was minimal. The base plate of intake well and the foundation were in close adhesion state in the whole process of earthquake, both sides and rear side of intake tower without through disengagement circumstances from rock. Based on the above results it may conclude that the intake tower is in the overall stability state.

Ravikumara H S (2015) in this paper the author investigates the dynamic behavior of circular intake towers. These towers are typically tall and hollow structures made of R.C.C. The circular intake towers are structurally more accomplished provides cost savings, especially in high-head projects. The dynamic parameters such as slenderness ratio, wall thickness and effect of depth of submergence are studied and also hydrodynamic effects are considered for using added mass concept. Apart from that the soil-structure-interaction analysis is carried out to study its effect on the dynamic behavior on the selected structure. The analysis software SAP 2000 is used for developing finite element models of intake structure soil using shell elements and solids respectively as well as modal and Response Spectrum analyses are carried out to determine the dynamic characteristics and response of the intake structure to earthquake stimulation for various geometrical parameters and different submergence conditions.

ISBN: 978-93-90214-19-8

After the complete analysis, the author concluded that, the water presence inside and outside of the tower for a fully submerged condition increases the fundamental time period due to the added mass. Due to increase in the slenderness of the tower, the fundamental time period increases. This is mainly due to the increase in flexibility of the intake tower. As the thickness of the intake decreased, self-weight of the tower decreases due to which the time periods also decreased.

Koji Hino, Mikio Nonaka, Ryoichi Fujita and Atsushi Mori (2015) in this paper the author investigate the seismic performance of a separated selective intake tower. The separated selective-intake tower is an asymmetrical slender R.C.C structure with multistage steel intake gates/ valves to regulate the flow so that the behavior of the structure is not simple during an earthquake. For the analytical studies a three-dimensional finite element model were prepared to carry out the investigation for the seismic performance of an existing intake tower against level 2 seismic motions defined as per the Japanese seismic design standards. To make an appropriate analysis model, a 3-D FEM model was calibrated by comparing observed seismic records of the existing intake structure. This study yielded practical information for analysis and design, mainly in terms of a modeling method and definitions of limit states for separated selective intake towers. In recent years the conditions of such civil structures after the earthquake proves that the there is no avoiding fact that intake towers need to be properly design. Seismic design of intake tower against level 2 earthquake motions is important because it governs the seismic performance of the structures. On the basis of analysis, the results were obtained from a limited number of cases and cannot be generalized. However, the results indicate that intake towers similar to the one considered in this study can be rationally designed to stay largely within the elastic response range when subjected to level 2 earthquake motions. The important thing in discussing the seismic performance of structures is to define seismic performance requirements and corresponding limit states and specific verification criteria.

Aidcer L. Vidot, Luis E. Suárez, Enrique E. Matheu, and Michael K. Sharp (2004) This Paper investigates the seismic response of intake-outlet towers. The effect of different ground accelerations at the supports of the tower and Approach Bridge is checked. The water outside and inside the structure is accounted for by added masses. The accelerations at the approach bridge support and intake tower base are calculated from a finite element model of the dam and soil foundation. The other effect considered is the soil-structure interaction. Two approaches for analysis is considered in this project, first one is a direct approach based on a finite element model of the tower, bridge, and dam with the earthquake motion applied at the bedrock is used. The second approach uses a frame model of the tower and bridge with springs and dashpots accounting for the soil-structure interaction. Analysis based on first method shows that the simple model provides appropriate results if adequate values of the torsional spring are used and also the results of second approach shows that the consideration of soil-structure interaction effects in analysis proved to be much more important than the multiple-support excitation.

Richard C. Dove and Enrique E. Matheu (2014) This Paper carried out the seismic performance evaluation of intake towers. In case of an earthquake, it is naturally important that the catastrophic failure of a dam and subsequent sudden release of the reservoir be prevented. A vital a part of the prevention of this sort of failure is preserving the potential to control the discharge of water after the earthquake. For maximum earthen dams, and some concrete dams, the discharge of water is managed through a R.C.C intake tower. The useful survival of such towers has been the principle challenge of a multi-year research effort sponsored by the U.S. Army Corps of Engineers (USACE). Most intake towers in the current U.S. Army Corps of Engineers inventory are light reinforced structures. The functional survival of such lightly reinforced intake towers is thus the principle difficulty of this research attempt. The main aim of this project work is the development of analysis procedures for seismic evaluation of these selected intake tower. After analysis it is demonstrated that the failure occurs under dynamic conditions was very similar to the failure mechanism previously observed under monotonic and cyclic loading. In both the static and dynamic experiments the same single crack response with significant ductility was witnessed. As expected the natural frequency of the model decreased substantially after cracking. Based on the results of static experimentation, this experiment validates the calculation of the deflection capacity. The authors also suggest the future work in which dynamic experiments will model the response of a tower to an individual earthquake because this experiment will validate the complete displacement based analysis process.

Ali Mahdian Khalili1, Bahram Navayi Neya, Leila Kalani Sarokolayi (2017) this paper investigates dynamic analysis of Intake Tower Considering sediments absorption. For this a selected reservoir intake tower with interior water of structure is analyzed using finite element method considering sediments absorption. To achieve this reservoir is modeled by Lagrangian approach and effect of sediments absorption on responses of selected structure is considered.. 3 types of sediments and also distance between dam and tower are determined for analytical studies. Dynamic analysis has been performed under vertical and horizontal excitation of Northridge and Tabas earthquakes. As per the analysis it is found that increasing distance between dam and tower can increase frequencies of intake structure system. The models with rigid sediments, the frequencies of system are a bit greater than model with two other types of sediments. Dynamic responses show that increasing the distance between dam and tower reduces the effects of sediments on the dam and tower responses. Based on the results it is concluded that the maximum displacements of dam crest and principal stresses of dam heel increase by increasing distance between them. In time domain responses, displacements of dam crest and principal stresses of dam heel increase in rigid sediments but sediment type has fewer effects on tower responses especially on displacements.

Mohammed Abdulkadir (2011) Generally, the Seismic analysis of an intake well carried out using traditional methods such as Response Spectrum (RSM), Modal-Time history (MTHM) and Seismic Coefficient (SCM), Equivalent Lateral Force (ELFM) Methods. Seismic Coefficient, Equivalent Lateral Force or Response Spectrum may produce response quantities with magnitudes bigger or smaller than those of refined method Modal-Time history. As compared to the traditional methods, how much variation are in the value magnitudes in comparison with those of the refined method. Simply, In other words, are the magnitudes of Seismic Coefficient, Equivalent Lateral or Response Spectrum Force overestimated or underestimated when contrasted with those of the refined method Modal-Time history method. The main objective of this study is answer these questions through detail investigation. To achieve objective, a detailed investigation of the seismic analysis methods for intake well structure was carried out. The investigation was carried out by performing elastic seismic analysis of a vertical free standing intake tower, using the traditional and refined methods; and the results of both the approaches are compared. The first step is to select a suitable intake tower and its location for the work. In this regard, the vertical free standing intake tower in kesem Dam irrigation project, in Afar Regional State, was selected. The selected site is largely prone to earthquake excitations. After selecting the intake tower and its location, the next step was material, structural as well as hydrodynamic modeling. After the Modelling, input ground motions in form of ground acceleration time-histories and response spectra were developed. After that seismic analysis of he selected intake well was carried out using these models and results were studied.

5. Gap Study

According to all the reviews, it is observed that there is a scope of work for dynamic analysis of the intake well by considering different parameters such as submergence condition, the ratio of outside radius to height of intake structure and wall thickness etc. which considerably affects the behavior of structure during the earthquake. So here we will try to calculate the seismic forces acting on the selected intake structure as per Indian Standard codes and also we will carry out dynamic analysis of the selected structure considering different parameters.

6. Conclusion

- It is extremely important to understand the dynamic behavior of an intake tower. However, the existence of water surrounding and inside the tower and the axisymmetric geometry makes the structure more complex.
- There is need to focus on seismic safety of structure using with respect to alternate

 ISBN: 978-93-90214-19-8

supporting system which are safe during earthquake and also take more design forces.

- The dynamic behavior of these structures during the event of earthquakes has to be investigated in detail in order to meet the safety requirements while containing construction and maintenance costs.
- In these papers, an attempt has been made to coordinate with standards & practices prevailing in different countries & assistance has been taken from various well prepared standards of developed nations & also from various revised/updated codes of India as well.
- The research's efforts in the area of reinforced concrete intake towers are currently focused on understanding the nonlinear response of lightly reinforced intake towers.
- The main focus is on the evaluation and development of simplified analysis procedures for the seismic evaluation of these structures.

7. References

1] Frank Lin, Norbert Bakkers, Michael Johnson, Yongwon Lee, Neil Southall, Zhenhong Wang, and Nigel White, "Challenge of Hydrodynamic Analysis for a Structure in Waves ", International Conference on Computers Management & Mathematical Sciences (ICCM 2014).

2] Kangning Dang , Yunhe Liu and Jingyi Zhang, "Dynamic response analysis of intake tower in hydroelectric power station with high surrounding rock", Chinese Journal of Underground Space and Engineering, Vol. 10, Issue 5, 2014, p. 1127-1134.

3]. U.S. Army Corps of Engineers, "Structural Design and Evaluation of Outlet Works", Engineer Manual, Washington, DC (2003).

4] Alok Goyal & Anil K. Chopra, "Hydrodynamic and Foundation Interaction Effects in Dynamics of Intake Towers: Earthquake Responses", Struct. Engrg., ASCE, 115(4), 1386-1395 (2004).

5] Liaw, C.-Y., and Chopra, A. K., "Dynamics of tower surrounded by water," Earthquake Engineering and Structural Dynamics 1(3), 33-49 (2004).

6] Richard C. Dove and Enrique E. Matheu, "Seismic Performance Evaluation of Intake Towers," 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada (2013)

7] IS 1893 (PART 1): 2002 Code of Practice for Earthquake Resistant Design of Structures Fifth Revision (Bureau of Indian Standards, New Delhi)

8] IS 1893 (PART 1): 2016 Code of Practice for Earthquake Resistant Design of Structures Sixth Revision (Bureau of Indian Standards, New Delhi).

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ISBN: 978-93-90214-19-8

Structural Audit of 40 year old Silo

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Abstract - In India structural stability of old structures and fire protection and safety is one of the most common issues. because the strength of old structures get reduced in due course of your time it generate structural flaws like material diminution, unexpected over loading, structural scarcity or physical damages and if further use of such damaged structure it's getting to leads to severe loss of human life and public property. As Structural Audit of old structure is obligatory as per municipal authorities and Government of Gujarat has made "Structural Audit" of all old structures compulsory. the most objective of present work is to adopt Structural Auditing of 40 years old silo which is situated at Somnath (Gujrat) with Schmidt's Hammer Test, Ultra Sonic Pulse Velocity Test, Cover Meter Test, Half-cell test, pH test including Visual Inspection and assessing the stableness and safety of the structure to confront to for its remaining life by diagnosis and root explanation for the issues with remedial measures. Based upon above test is observed that the attribute of concrete is medium at maximum locations and Doubtful at few locations, corrosion has started in reinforcement and well within the suitable limit. Hence, it's recommended to repair damaged areas as per the methodology, specifications and locations.

Keywords: PH test, Half-cell test, Ultrasonic pulse velocity test, Rebound hammer test, NDT method, Structural Assessment Program

Introduction

Structures are assemblies of load carrying members capable of safely transferring the superimposed loads to the foundations. because the structure gets older and older as time goes, during this due course of your time structures have reduced strength thanks to material deterioration, unexpected over loading, structural deficiency or physical damages. If, further use of such deteriorated structure is sustained it's going to cause severe loss of life and property. We all agree that each life is precious and each structure is, in a way, a national asset, therefore, there's need of periodical maintenance and checkup to stop future damages. Structural Audit may be a preliminary technical survey of a building to guage the strength so on improve its appropriateness, safety, efficiency. The Audit highlights & investigates all the danger areas, critical areas of the Building and also suggests if building needs immediate attention. The Structural Audit is administered by appointing a Structural Engineer. He examines the structure by visual inspection of the Building and if required the Non Destructive Tests are administered consistent with requirement of structure. the aim of building standard procedures for nondestructive testing (NDT) of concrete structures is to qualify and quantify the fabric properties of in-situ concrete without causing damage. The range of properties which will be assessed using non-destructive techniques is large and includes fundamental parameters of the Concrete like density and coefficient of elasticity additionally to strength. Other properties which may be assessed include concrete surface hardness, Surface absorption and moisture condition also as reinforcement location, cover and corrosion risk. Government of Gujarat has made "Structural Audit" of all old building compulsory as per the great General Development Control Regulations enforcing from 12/10/2017.As per Schedule 17 (Schedule for Maintenance and Inspection for Structural Stability and Fire Safety) and Form 15. Structural Audit is mandatory for all Industrial Structures as per corporation directive and as follows:-

Age of the Structure	Structural Audit (Compulsory)
15 to 30 years	Once in 5 years
Above 30 years	Once in 3 years

OBJECTIVES

The crucial objective of present work is to adopt Structural Auditing of 40 years old silo which is situated at Somnath (Gujrat) with Schmidt's Hammer Test, Ultrasonic Pulse Velocity Test, Cover Meter Test, Half-cell test, pH test including Visual Inspection And Assessing the stability and safety of the structure to withstand for its remaining life by Diagnosis and root cause of the problems with remedial measures.

METHODOLOGY

The methodology of the project comprises of four major stages which are as follows:

Visual Observation is one among the foremost important step in non-destructive tests. It include as an example, cracks, pop- outs, spalling, disintegration, colour change, weathering, staining, surface blemishes and deficiency of uniformity From Visual Inspection, As an engineer it's duty to collect information which is useful to understand condition of the structure and permit formulization of a subsequent testing programme and suggest reparing methodology.

Rebound Hammer Test the tactic is predicated on the principle that the rebound of an elastic mass depends on the surface hardness averse which mass strikes. When the plunger of rebound hammer is pressed on the surface of the concrete, the spring controlled the mass of rebounds, Hence the extent of such rebound depends on the surface hardness of concrete. Rebound are related with the compressive strength of the concrete. The rebound number and index are read from graph provided on rebound hammer along a graduated scale. For finding the measurement, the hammer should be place at right angles to the concrete surface. The test are calculated horizontally on vertical surfaces and vertically upwards or downwards on horizontal surfaces.

Rebound Criteria for Quality of Concrete Grading as per (IS 13311 Part II)

Average Rebound	Quality of Concrete
>40	Very Good hard layer
30-40	Good
20-30	Fair
<20	Poor concrete
0	Delaminated

Fig No-1.Rebound Hammer

are converted into an electrical signal by a second transducer. Electronic timing circuits enable the transit time T of the pulse to be measured and the pulse velocity is determined by path length by transit Time. Pulse Velocity in concrete will be represented in Km/sec or M/s. The instrument indicates the time taken for the earliest a part of the heart beat to succeed in the receiving transducer measured from the time it leaves from an appropriate point on the surface of the material.

The pulse velocity is determined by the equation: -

$$\textbf{Pulse Velocity} = \frac{Path\ Lengt}{Trans\ \ Time}$$

Ultrasonic Pulse Velocity Test A throb of longitudinal vibrations is produced by an electro-acoustical transducer, which is held in touch with one surface of the concrete under test. When the throb generated is transmitted into the concrete from the transducer employing a liquid coupling material like grease or cellulose paste, it undergoes multiple reflections at the boundaries of the varied material phases within the concrete, a posh system of stress waves develops, which include both longitudinal and shear waves, and propagates through the concrete. The primary waves to achieve the receiving transducer are the longitudinal waves, which

ISBN: 978-93-90214-19-8

Fig No.2-U.P.V Test

The instrument indicates the time taken for the earliest a part of the heart beat to succeed in the receiving transducer measured from the time it leaves from an appropriate point on the surface of the material.

The path length and transit time are measured to determine the pulse velocity. The velocity of longitudinal pulse in elastic solids. It are often shown that the speed V of pulse of longitudinal ultrasonic vibration traveling in an elastic solid is given by:

$V^2 = E (1-\mu) / p (1+\mu) (1-2\mu)$ (B.S. 1881 Part 203 - 1986)

Where, E is the dynamic elasticity modulus P is the density

μ is the Poisson’s ratio.

As per IS 516 (Part 5/Sec 1):2018 Table 1 velocity criterion for concrete Quality Grading

Velocity Criteria for Quality of Concrete Grading

Pulse Velocity	Quality of Concrete
Above 4.5 Km/Sec	Excellent
3.5 - 4.5 Km/Sec	Good
3.0 - 3.5 Km/Sec	Satisfactory
Below 3.0 Km/Sec	Doubtful

Pulses aren't transmitted through large air voids during a material and if such a void lies directly within the pulse path the instrument will indicate the time taken by the heart beat which followed quickest route. It’s thus possible to detect large voids when grid of pulse velocity measurement is formed over a neighborhood during which voids are located.

The pulse velocity method of testing could even be applied to the testing of plain reinforced and pre-stressed concrete whether it's pre-cast or cast in-situ. The measurement of pulse velocity could also be wont to determine. The homogeneity, void cracks, changes in concrete such as chemical attack, quality, of concrete.

Half Cell Test- The half-cell potential method measurements normally involves measuring the potential of an embedded reinforcing bar relative to a reference half-cell placed on the concrete surface. The half-cell is typically a copper/copper sulphate or silver/silver chloride cell but other combinations are used. The concrete functions as an electrolyte and therefore the risk of corrosion of the reinforcement within the immediate region of the test location could also be related empirically to the measured electric potential difference. In some circumstances, useful measurements are often obtained between two half-cells on the concrete surface. ASTM C876 - 91 gives a typical Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete. Risk of Corrosion Against Potential Difference Reading. This technique is presumably to be used for assessment of the sturdiness of reinforced concrete members where reinforcement corrosion is suspected.

Fig No.-3.Half cell test

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Corrosion Criteria

Half-cell potential (mv) relative to Cu-Cu sulphate Ref. Electrode	% chance of corrosion activity
Less than -200	10%
Between -200 to -350	50% (uncertain)
Above -350	90%

Cover Meter Test a cover meter is a device designed specifically for determining the "cover" to reinforcement bars in concrete. Location of embedded rebar's & estimation of size of embedded rebar's. Cover is defined as being the distance from a given surface of a concrete element to the nearest part of a reinforcement bar or other embedded item. Knowing the diameter of the bar and their location is essential to understand the bar spacing and their placement, in existing structures where there are not any structural drawings available. The cover thickness is significant from the aim of view of estimation of initiation of corrosion. Cover meter is significant to form sure longer life for the structure. shrinkage. The method to establish the extent of carbonation in concrete by applying a solution of 15mg Phenolphthalein & 10ml Ethanol diluted in 50ml of distilled water to a fresh fracture surface of concrete. The change of Pink color of concrete indicate carbonation free concrete while the uncolored indicated carbonation. The pH of concrete lowers when the carbon dioxide in the air comes in contact with concrete, the process is called carbonation. A standard pH meter is used to measure the pH of concrete. If pH value between 7 to 9 Concrete stats to break down and pH of the concrete below 8.6, suggesting carbonation.

Fig No.4-Cover merer

pH Test when the CO2 in atmosphere within the presence of moisture reacts with hydrated cement, Carbonation of concrete occurs. Carbonation process is additionally called as depassivation. Carbonation of concrete is related to the corrosion of steel reinforcement and with

Fig No.-5.PH TEST

ISBN: 978-93-90214-19-8

RESULTS

Table-1.Rebond Hammer Test Results

Sr.No.	Particulars	Rebound No	Average	Probable Compressive Strength (N/mm^2)
Raw Mill Silo				
1.	West Side At 40 Mtr Level	38,32,34,36,32,40,34,36,34,40,38,36	36	37
2.	West Side At 30 Mtr Level	30,32,36,34,36,38,32,34,36,32,36,34	34	34
3.	West Side At 20 Mtr Level	30,36,32,38,34,40,38,36,34,38,38,36	36	37
4.	West Side At 10 Mtr Level	32,30,26,32,32,28,26,32,36,32,30,28	30	27

Table-2. U.P.V Results

Sr.No.	Description	Particular	Transit time in Micro Seconds (T)	Path length (L) (mm)	Velocity V=(L/T) (in KM/Sec)	Factored value of U.P.V. in Km/sec	Remark
Raw Mill Silo							
1.	West Side At 40 Mtr Level	Indirect	106	200	1.89	2.89	Doubtful
		Indirect	112	200	1.79	2.79	Doubtful
		Indirect	119	200	1.68	2.68	Doubtful
2.	West Side At 30 Mtr Level	Indirect	93	200	2.15	3.15	Medium
		Indirect	98	200	2.04	3.04	Medium
		Indirect	96	200	2.08	3.08	Medium
3.	West Side At 20 Mtr Level	Indirect	97	200	2.06	3.06	Medium
		Indirect	98	200	2.04	3.04	Medium
		Indirect	103	200	1.94	2.94	Doubtful
4.	West Side At 10 Mtr Level	Indirect	95	200	2.11	3.11	Medium
		Indirect	91	200	2.20	3.20	Medium
		Indirect	106	200	1.89	2.89	Doubtful

Table-3.Half Cell Results

Raw Mill Silo		
SR. NO.	**PARTICULARS**	**HALF CELL**
1.	West Side At 25 Mtr Level	-345
		-376
		-402
		-366
		-365
		-389
		-432
		-378
		-405
		-289

Note-Below -250 NO Corrosion, -250mv to -350mv Possibility of Corrosion, Above -350 mv Active corrosion.

Table-4.Cover Meter Test Results

SR.NO.	**DESCRIPTION**	**COVER TO THE REINFORCEMENT IN(MM)**
Raw Mill Silo		
1.	West Side At 40 Mtr Level	59,66,67,68,69,102
2.	West Side At 30 Mtr Level	54,69,59,55,68,69
3.	West Side At 20 Mtr Level	77,74,69,79,67,66
4.	West Side At 10 Mtr Level	63,66,67,102,79,77

Table-5.PH Test Results

SR. NO.	**PARTICULARS**	**POTENTIAL MV**		**pH**
		40mm	**80mm**	
Raw Mill Silo				
1.	West Side At 40 Mtr Level	-261	-253	11.95to12.42
2.	West Side At 30 Mtr Level	-242	-256	11.91to11.96
3.	West Side At 20 Mtr Level	-226	-254	11.63to12.98
4.	West Side At 10 Mtr Level	-230	-259	11.95to12.42

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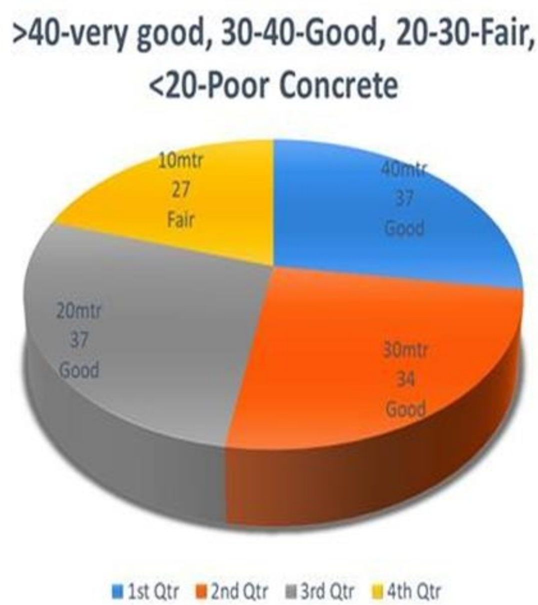
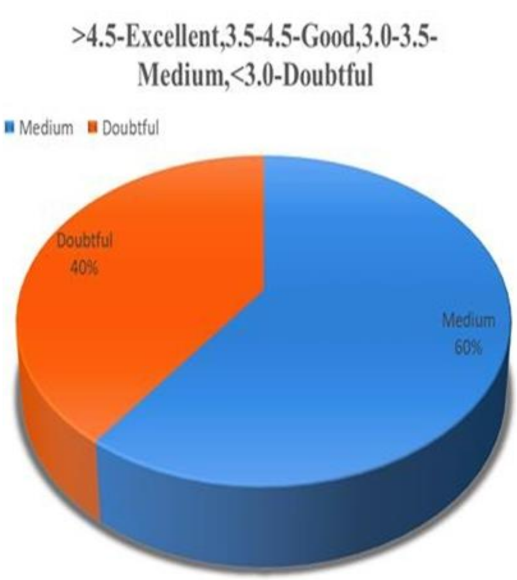
Pie Charts Shows Results-

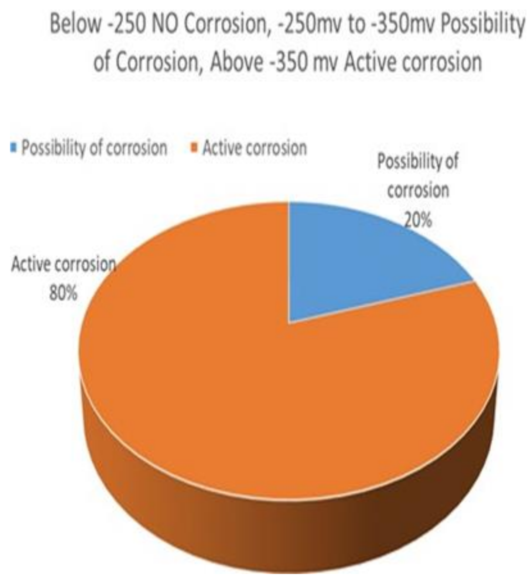
1. Rebound Hammer Test Results



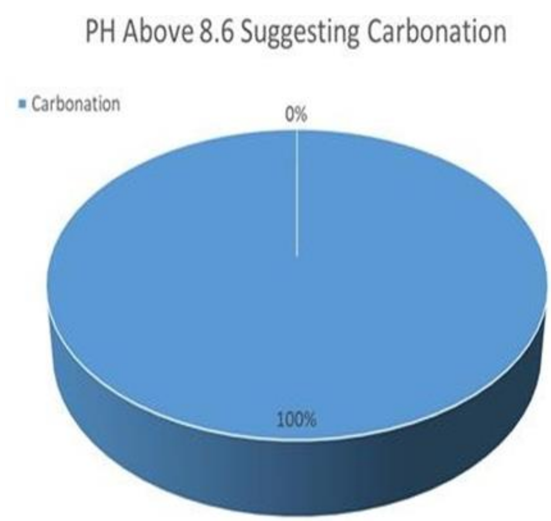
2. U.P.V Test Results



3. Half Cell Test Result



4. PH Test Result



CONCLUSIONS

Based on all Nondestructive test results R.C.C silo needs structural strengthening and repairing work with help of injection grouting and polymer concreting work and rebaring whenever need and some places need micro concreting and Anodic protection for steel corrosion and for paint anti

ISBN: 978-93-90214-19-8

corrosive paint which side reinforcement exposed two coat of anticorrosive paint and polymer concreting is required.

REFERENCES

[1]. Nondestructive testing of concrete method of test (Ultra Sonic Pulse Velocity) IS 13311 (Part I) 1992
[2]. Schmidt hammer IS 13311 (Part II) 1992
[3]. Code of practice for reinforced concrete IS 456-2000
[4]. Method of tests for strength of concrete IS 516-1959
[5]. Strength evaluation of existing concrete building report by ACI committee 437 ACI-437R-91 [6]. Corrosion of metal in concrete Part I report by ACI committee 222
ACI-222R-89
[7]. pH value B.S. 5741-1991
[8]. Dr. Dilip P. Mase, A Case Study of Structural Assessment and Auditing report for Residential Building Nagpur (Maharashtra), August 2018.
[9]. BS 1881: Part 201: 1986 British Standard Testing concrete Part 201. Guide to the use of nondestructive methods of test for hardened concrete.

 ISBN: 978-93-90214-19-8

Effect of Blast Furnace Slag Cement on Strength of Structural Concrete in Costal Region

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Abstract - This research topic is focused on the ability of concrete mode of mortar mixture with different cement types which when exposed to chloride and sulphate in marine environment affect their strength and durability of the concrete.

The source of sulphate may either external or internal. The internally occurring sulphate in the environment like sea water on the sulphate which are the products of industrial wastes. Internal source of sulphate is the composition of chlorides plus sulphates introduced in the cement during manufacture.

The specimens made of different cements are subjected to the standard test which evaluates the resistance of concrete to chloride and sulphate which are present in the sea water.

Keywords: Blast Furnace Slag Cement, Compressive strength, Sea water.

Introduction

The entrance of chloride particle (which comes from salt containing chlorine) through pores into porous cement is called Chloride entrance. Unwavering quality of cement and RC designs can be guaranteed through precise expectation of administration life, which is impacted by a few falling apart factors. The exhibition boundaries utilized for cement and RC constructions can be ordered dependent on the decay Attributes like physical, compound and electrochemical boundaries. For example, synthetic attributes, for example, calcium hydroxide content, qualities of beneficial cementitious materials, the level of hydration, pozzolanic response, pH of solid, chloride dissemination coefficient and chloride relocation coefficient are found to impact the chloride limit level of built up solid This training is in suitable and frequently prompts horribly wrong assessments of chloride edge esteem. The extent of the investigation is to improve the comprehension of debacle danger, risks, and weaknesses and upgrade catastrophe readiness for successful reaction.

The capacity of cement to oppose chloride particle infiltration is one of the basic boundaries, which should be viewed as with regards to opposition and sturdiness issues of solid constructions. Particularly on the grounds that chloride particle infiltration can be the reason for chloride actuated erosion. The principle wellspring of chloride particles are seawater, harsh groundwater and deicing salts utilized in winter on street structures

Reasons for Chloride Assault on Cement

The assault of chloride on cement can be happened either from within the solid or through the entrance of chloride from outside to within solid designs.

Contrasting both the methods for chlorides, the odds of outside chloride activity are high. The vast majority of the seaward constructions are exposed to extraordinary chloride assaults. This incites support consumption of designs. In all actuality, the activity of chloride in inciting consumption of support is more genuine than some other reasons. One may comprehend that Sulfates assault the solid while the chloride assaults steel fortifications.

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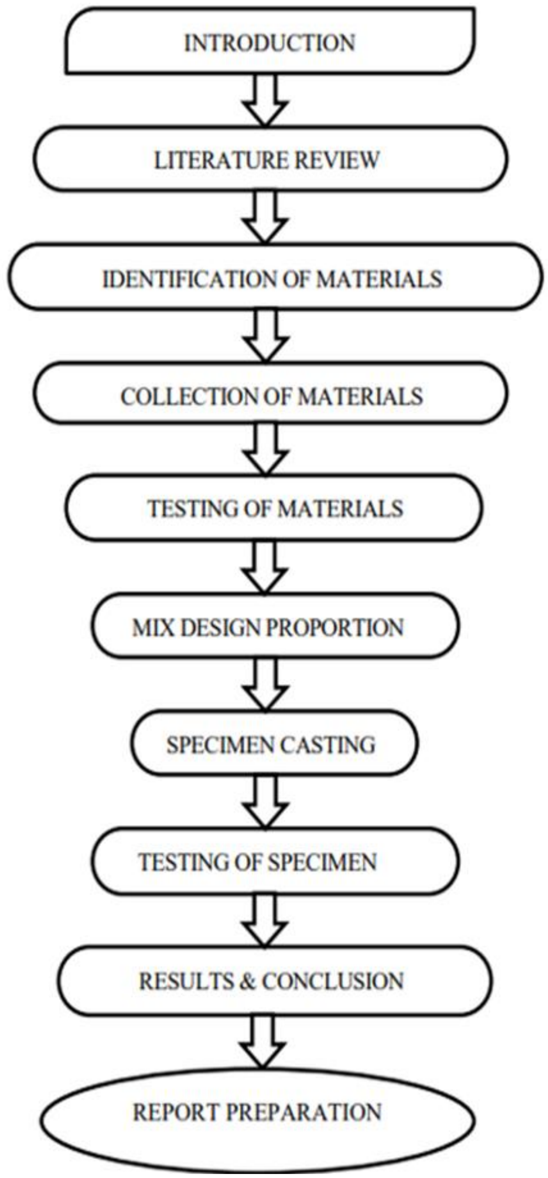
II.METHODOLOGY



III. EXPERIMENTAL INVESTIGATION AND MATERIALS USED

PRELIMINARY INVESTIGATION

Preliminary investigation is carried out to determine the properties of Cement, fine aggregate, coarse aggregate and water sample.

*Test on Cement
- Standard Consistency of Cement
- Initial setting time

*Test on Fine Aggregate
- Specific Gravity
- Sieve Analysis

*Test on Coarse aggregate
- Impact Test

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- Los Angeles Abrasion Test on Aggregates

*Test on Water Sample

- Bore Water
- Sea Water

STANDARD CONSISTENCY OF CEMENT

Table. I. Observation for consistency of cement (Sulphate resisting Portland cement)

S.NO	Wt. of cement(g)	Quantity of water added (%)	Wt. of water added(ml)	Depth of Penetration
1.	250	25	62.5	39
2.	250	27	67.5	36
3.	250	29	72.5	32
4.	250	31	77.5	16
5.	250	22	80.0	7

Result: Percentage of water content for standard consistency is 32%

INITIAL SETTING TIME

Table. II Initial setting time of cement

S.NO	Description	Penetration
1.	Ordinary Portland cement	30 min
2.	Portland pozzolana cement	30 min
3.	Sulphate resisting Portland cement	80 min
4.	Blast furnace slag cement	60 min

SPECIFIC GRAVITY OF FINE AGGREGATE

Table III. Observation to find out specific gravity

S.NO	Description	Observed value
1.	Weight of empty Pycnometer: W1 g	652
2.	Weight of aggregates and Pycnometer: W2 g	902
3.	Weight of aggregates, Pycnometer and water: W3 g	1656
4.	Weight of water and Pycnometer: W4 g	1484
5.	Apparent Specific Gravity: (W2-W1)/[(W2-W1)-(W3-W4)]	2.6

Result: Specific gravity for fine aggregate =2.6

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SIEVE ANALYSIS ON FINE AGGREGATE

Table VI Sieve Analysis of fine aggregate

S.NO	Size sieve in mm	Weight of soil retained(gm)	% retained	Cumulative weight Retained(gm)	% finer
1.	4.75	36	7.20	7.20	92.80
2.	2.36	72	14.40	21.60	78.40
3.	1.18	128	25.60	47.20	52.80
4.	0.6	75	15.00	62.20	37.80
5.	0.425	64	12.80	75.00	25.00
6.	0.3	46	9.20	84.20	15.80
7.	0.15	32	6.40	90.60	9.40
8.	0.075	28	5.60	96.20	3.80

Table: Gradation Table of fine aggregate

SL.NO.	Description	Test Results	Reference	Remarks
1.	Coefficient of uniformity (Cu)	8.82	IS 383-1970	Well graded sand Cu≥6
2.	Coefficient of Curvature (Cc)	1.11	IS 383-1970	Well graded sand 1≤Cc≥3
3.	Grading Zone	Zone II	IS 383-1970	As per % passing

IMPACT TEST ON COARSE AGGREGATE

S.NO	Description	Test 1	Test 2	Test 3
1.	Wt. of empty cup (W1)	1.775	1.775	1.775
2.	Wt. of empty cup and aggregate (W2)	2.10	2.089	2.100
3.	Wt. of aggregate (A)	0.325	0.314	0.345
4.	Wt. of aggregate through IS Sieve (2.36) (B)	0.077	0.070	0.092
5.	Aggregate Impact value(B/A) X100	23.69	22.29	26.66

Result of Impact Test:

Coarse Aggregate Impact Value = 23.69 + 22.29 + 26.66 = 24%

LOS ANGELES ABRASION TEST ON AGGREGATES

Table.VI Observation for abrasion test

S.NO	Description	Sample
1.	Wt. of Coarse aggregate(W1)	5 kg
2.	Wt. of aggregate sample retained(W2)	4.372 kg
3.	Weight passing 1.7mm IS sieve(W1-W2)	628 g
4.	Abrasion Value = (W1 – W2) / W1 X 100	12.56%

Result: Los Angeles Abrasion Value = 12.56%

 ISBN: 978-93-90214-19-8

CHEMICAL TEST ON WATER SAMPLES

Sample Analyzed as per IS: 10500-2012 (Bore water and Sea water)

Table.VII Chemical Content on Water Samples

S.NO	Parameters	Bore water	Sea water	Requirement as per IS 10500-2012
1.	Chloride (as Cl)	375 mg/l	12000 mg/l	250 mg/l
2.	Sulphate (as SO4)	92 mg/l	1830 mg/l	200 mg/l

Cubes and cylinders are casted for this experiment using cement, fine aggregate and coarse aggregate for the design mix proportion to determine the compressive, split tensile, flexural strength, diffusion test, Rapid chloride permeability test (RCPT) respectively. A total number of 32 specimen are prepared for the experiment. The details of the specimen can be shown in Table.

IV RESULTS AND DISCUSSION

RESULTS

The specimens will be tested to find

• Compressive strength test

Compressive strength test

Compressive strength of concrete cubes of 150mm at 7, 14 and 28 days for various sorts of concretes. The highest compressive strength of cement concrete is found in Sulfate Resisting cement concrete. Tables show the compressive strength for 7, 14 and 28 days of curing.

V CONCLUSION

Based on the results of experimental investigation conducted on concrete specimens made with different types of cement, the following conclusions are made:

- In a comparison of OPC and Slag cement concrete, at 7 days bore water curing compressive strength of slag cement concrete obtained as 12.24 % more and at 7 days sea water curing compressive strength of slag cement concrete obtained as 16.75% more when compared to OPC concrete.
- In a comparison of OPC and Slag cement concrete, at 14 days bore water curing compressive strength of slag cement concrete obtained as 11.23 % more and at 14 days sea water curing compressive strength of slag cement concrete obtained as 12.32% more when compared to OPC concrete.
- In a comparison of OPC and Slag cement concrete, at 28 days bore water curing compressive strength of slag cement concrete obtained as 4.2 % more and at 28 days sea water curing compressive strength of slag cement concrete obtained as 8.9% more when compared to OPC concrete.
- It is observed that, bore water curing concrete specimens has low compressive strength when compared to sea water curing concrete specimens at early ages and with age increasing, the percentage increase of compressive strength is reducing.
- The slag cement concrete has higher compressive strength when compared to OPC concrete

REFERENCE

As per Indian standard (Code Book)

❖ IS 456-2000 (Plain and Reinforced Concrete)

❖ IS 269 1989, IS 8112-1989, IS 12269-1987 (OPC 33, 43, 53 Grade)

❖ IS 12330-1988 (Sulphate resisting Cement)

❖ IS 455-1989 (Portland Slag Cement)

❖ IS 10262-2009 Concrete mix design)

- Erhan Guneyisi, Turan Ozturan, Mehmet Gesog (June 2016) Department of Civil Engineering, Gaziantep University, 27310, Gaziantep, Turkey
- Yu Wang, Long-yuan Li, C.L.Page (Feb 2005) Department of civil & environmental engineering ,Imperial college , London SW7 2BU, UK.
- Byung Hwan Oh, Bong Seok Jang (Jan 2003) School of Civil Engineering, University of Leeds, Leeds LS2 9JT, UK.

ISBN: 978-93-90214-19-8

- C. Alanso, C.Andrade (July 1998) Eduardo Torroja, Institute of construction and cement , Madrid.
- R.M Ferreira, J. P. Castro-Gomes, P. Costa, R. Malheiro (August 2015) VTT Technical Research Centre of Finland, Espoo, Finland.
- Luz Marina Torrado Gomez, Norma Cristina Solarte Vanegas (Sept 2017) Universidad Pontificia Bolivariana Bucaramanga, Colombia.
- Jin Di, Cunjun Pang, Xiaoqing Xu (Dec 2018) College of Civil Engineering, Chongqing University, Chongqing, China.
- S Mahima, P V P Moorthi, A Bahurudeen, Athira Gopinath (Feb 2018) Department of Civil Engineering, Indian Institute of Technology, Kanpur, India.
- Sanjeev Kumar Verma, Sudhir Singh Bhadauria, Saleem Akhtar (Dec 2013) S.G.S. Institute of Technology and Science INDORE, Madhya Pradesh, India.
- Chung, Jee-Seung, Kim, Bo-Heon (July 2014) Department of Rail road Civil Engineering, Dongyang University

Application of Different Types of Soil Nails for Slope Stabilization

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Abstract— The major problem in the construction industry is the failure of slope or excavation, to avoid its risk on human lives and properties many techniques are in use, Soil nailing technique is one of the most widely used techniques from the last four decades. It consists of solid or hollow steel bars that behave as passive reinforcement encased in grout at an inclination to the horizontal into the soil with definite horizontal and vertical spacing. In general, when compared to other traditional slope stabilization methods like soil anchors, retaining walls, etc. the soil nailing system has the many advantages of lower cost, quicker and easy construction procedure, and less impact to the nearby ground structures. There are different types of soil nails that need to be studied before their application in slope stabilization. So, this paper presents the use of different soil nails and some previous researches for the improvement of slope stability and stabilization of a vertical cut using these nails.

Index Terms— ***Soil nailing, Soil nails, Soil stabilization, Vertical cut.***

I. INTRODUCTION

Soil is a loose fine material that fails in shear. To improve its shear strength so that it cannot fail is done by slope stabilization technique. Soil failure along its shear plane is also known as landslide which is very dangerous for human life as well as in construction areas. To reduce landslide failure many techniques have been adopted. Soil nailing is one of the advantages techniques used among all of them from the last four decades. It includes solid or hollow steel bars which behave as passive reinforcement. They were constructed in the top-to-down manner so also known as the top-down technique. This helps in the easy construction of soil nail walls without interfering with the ongoing traffic for the road widening project.

This technique was initially developed in Europe and then adopted by many countries for the stabilization of artificial and manmade slopes. The conventional type of soil nailing comprises of insertion of steel bars to passively strengthen the soil. These steel reinforcements are inserted at an angle to horizontal and can be placed in a pre-bored hole and then encased in cement grout. The major drawback of the conventional type of soil nails are they dependent on the construction process of the soil nail wall and the type of soil and the performance is also very much depending on the pullout capacity. Pullout capacity or resistance depends on soil properties, nail properties, overburden pressure, and grout pressure. Another issue is the problem of bridging in conventional soil nailing. This means that while drilling the stresses in surrounding soil release. The pullout resistance is then independent of the surcharge pressure. Another difficulty is that in predrilled hole centralized bar is placed to ensure the soil nail should be placed centrally. The poor centralizer results in poor bending resistance and hence results in cracking of grout and breaking of nail. So, the main concern of the nails is their pullout capacity. To improve the pullout capacity various types of modification in nails have to be done by various researchers.

II. TYPES OF SOIL NAILING TECHNIQUE

Soil nailing technique is extensively using in slope stability of deep vertical cut and other excavation slopes. There are many types of soil nailing methods which are used to stabilize the soil slopes according to the nail installation process:

1. Drilled and grouted soil nailing

In this nail installation process, first the borehole is drilled on the soil surface and then the nails are inserted into this pre-drilled hole. Centralized bars are placed in between the hole to ensure the proper centralization of the nail. The drilled hole is then filled with cement grout. This method is most commonly used in stabilizing the slope.

ISBN: 978-93-90214-19-8

Fig.1: Drilled and grouted soil nailing method

2. Driven soil nailing

In this type of driven soil nailing method, nails are directly driven to the soil during the excavation process. Installation of the nail is faster in this method due to the small diameter of the nail. This type of nailing does not provide good corrosion protection so mainly used for temporary application.

Fig.2: Driven soil nail method

3. Self-driven soil nail method

This type of method contains hollow steel bars that are drilled and grouted simultaneously. This process of installation is faster than grouted soil nailing process. Some corrosion protection is provided by this method due to the presence of grouting.

Fig.3: Self-driven soil nail method

4. Jet grouted soil nail method

In this technique to install the nail to the final location grout jetting is done for eroding the ground and advancing the hole. After advancing the hole by jetting, steel bars are placed in the hole by the Vibro-percussion drilling method. Corrosion protection is also provided by the grout present in between nail and hole.

Fig.4: Jet grouting soil nail method

5. Launched soil nail method

In this method, nails are forcedly inserted into the soil at a very high speed by compressed air. This technique is fast and has less impact on the ground. It is difficult to control the length of penetration of nails in this process.

Fig.5: Launched soil nail method

4. **Nail head-** It acts as a reaction pad for creating tensile force in the nails and it also intercepts the local failure between the nails.

5. **Hex nut, washer, and bearing plate-**These are used to join the nail to the facing and form the intrinsic part of the nail head.

6. **Temporary and Permanent Facing-** Facing provides additional support to the soil nail system. After installation of nails, facing is provided by shotcrete or other methods. After temporary facing, permanent facing is installed over it.

7. **Drainage System-** It is mandatory to construct a drainage system to prevent any seepage against the excavation face. Generally vertical geocomposite strip drains are used as a drainage system.

III. COMPONENTS OF A SOIL NAIL WALL

The main components or parts of a soil nail wall are varied depending upon the techniques used for the installation of nails as given above.

The various elements of a soil nail (Figure 5) can be shown as follows

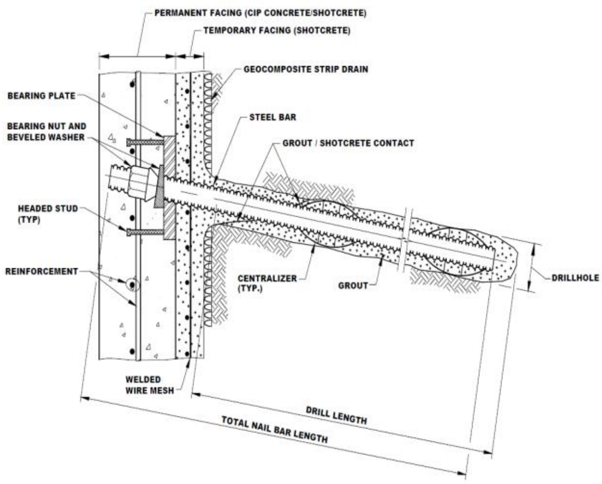

Fig. 6: Main Components of a Typical Soil Nail

1. **Steel bar-** It is also known as a nail and acts as a tension member. It the main component of the soil nail system. Nails can be used as solid or hollow according to the application.

2. **Centralizers-** It is placed in between the hole to ensure that nail can be placed centrally in a drill hole.

3. **Grout-** It is used for filling the hole after placing the nail. It provides bonding between the nail and hole and also gives corrosion protection to the nail.

IV. REVIEW ON DIFFERENT SOIL NAILS

There are many types of soil nails that are used for slope stability purposes. Some of the soil nails reviewed by various researchers are prescribed below for their application.

1. Screw soil nail

H. Tokhi, G. Ren, and J. Li carried out an experimental study on screw nails in dry sand to compare its performance with other conventional type soil nails. This study includes series of laboratory pullout tests on screw nails on cohesionless soil. The experimental study was performed on the fabrication of a large pullout box, filled with cohesionless soil followed by a thin vertical band of colored sand so that the rupture zone can be examined properly. The result of the experimental study shows the difference in pullout resistance between conventional soil nails and screw nails. The pullout capacity of screw nails comes to be on the higher side. From the observations, it was concluded that screw nail offers many advantages over conventional soil nails like easy installation with no grouting required, better soil-nail interaction results in better pullout capacity. The potential use of this type of nail is more advantageous in areas where granular soil is present and areas of limited access.

Rawat S. and Gupta A. S. performed experimental and numerical modeling on soil slopes reinforced by screw nails. Their models had soil slopes of 45^o and 90^o with the horizontal. Six screw nails were inserted at 0^o inclination with horizontal to stabilize the soil slope. Then load was applied on the slope crest and the failure mechanism was noted on smooth versus screw nailed system. This study also shows slope deformation, crest settlement, and failure mechanism of screw nailed soil slope. Numerical modeling has also been carried out to find out factors of safety along with failure slip surfaces of soil slopes with smooth nails and screw nails. The result showed a higher factor of safety and a decrease in slope displacement in screw nailed slope. It was concluded that

ISBN: 978-93-90214-19-8

screw nails produce greater interface friction between soil and nail as compared to smooth nails because of the threaded surface.

2. Compaction grouted soil nail

Xinyu Ye, Qiong Wang, Shanyong Wang, Scott Sloan, Daichao Sheng proposed a new soil nail called compaction grouted soil nail. They are the combination of conventional soil nails followed by compaction grouting using a membrane. They performed physical modelling to know the pull-out behaviour of compaction grouted soil nails under different grouting pressures. They also carried out interface shear tests to evaluate the peak pull-out resistance of the conventional soil nail and results were compared between the pull-out resistance of the compaction-grouted soil nail and conventional soil nail. They showed that an increase in grouting pressure increases the pull-out resistance of the compaction-grouted soil nail. This new soil nail gives more stability to large deformation areas. The rate of increase of grouting pressure is higher in compaction-grouted soil nails than conventional soil nails. They showed with the results that compaction-grouted soil nails are more effective than conventional soil nails.

3. Hollow core soil nail

Hollow core bar has been adopted by the United States to replace the traditional method of self grouting soil nails. These hollow bars are more advantageous than solid bars as they involved fewer installation steps and having a better grout-grout bond. In loose soil with cobbles and boulders, the casing is required to support the excavation hole for the installation of solid nails and therefore becomes a costlier and slower process. So FHWA guided the alternate technique of hollow bar soil nails fitted with an over-sized, sacrificial drill bit that behaves as a cutting tool for advancing borehole. This drill bit has 2 to 5 holes based on the soil type and allows the grout into it that facilitates the drilling process. In this construction technique drilling, installation, and grouting of nails are generally faster than conventional drill and grout technique of soil nail bars (FHWA 2016).

4. Launched soil nail

G. Murray, W. Okada, R. K. Barrett, L. D. Houghton, and G.P. Quickfall have studied launched nails and suggested that these soil nails are suitable for both temporary and permanent construction work for steep slope stabilization. These nails were invented by British Ministry where six-meter-long nails were fired into the ground using high compressed air in a single shot. Afterward, these launched nails were widely used by UK, USA, and New Zealand. As the name suggested they are not drilled, driven, or grouted into the soil- they launched into the soil. They are advantageous to the conventional type of soil nails in many ways like quick installation, no scaffolding required, cost-effective, and longer life. Launched nails can be used in gravel, sand, clay, and silt or a mixture of these but the soil does not contain a high percentage of cobbles and boulders.

5. Helical soil nail

M. Sharma, M. Samanta, and S. Sarkar performed laboratory testing for the pull-out capacity of the helical soil nail. For this test was carried out on seven different types of helical nails and showed that peak pull-out capacity influences by the roughness of the nail shaft. A linear relationship between overburden pressure and peak pull-out capacity was also observed indicating that they follow Mohr-Coulomb failure criteria. The results indicate that helical soil nail with double helix of equal diameter shows more pull-out capacity than helical soil nail with double helix of unequal diameter. Helical nails are a new idea to replace conventional soil nails for stability of soil slopes, deep vertical cut, excavations, and embankments as they are easy in installation process, minimized the adjacent site disturbance and improved load bearing capacity.

6. Geonail

Y. M. Cheng, S.K. Au, A.M. Pearson, and N. Li have done laboratory and in-situ tests to study the performance behaviour of geonail for the stabilization of soft soil. They performed various tests like cone penetration test, Dilatometer test, vane shear test, and plate load test and found that the geonail system is more effective than the classical soil system for the stabilization of the soft ground condition. It is a new innovative nail that is a combination of fracture grouting and composite glass fiber-reinforced plastic (GFRP) soil nails to stabilized the soft clay soil. As soil nail is not much effectively work in soft clay, therefore, geonail can be used in this condition and it increases the pullout resistance of the soil and also a cost-effective method. Geonail was successfully adopted for the construction of the airport link in soft clay in Australia.

7. AKARPILES

AKARPILES are an innovative solution for soil stabilization proposed by Chun-Lan Lim and Chee-Ming Chan. These soil nails were originated in Malaysia as landslide becomes the common problem there that causes damages, impact on the economy, and safety of the public and environment. The concept of AKARPILE includes grouting and soil nailing. The idea comes from a tree root system where root patterned piles are used to

ISBN: 978-93-90214-19-8

hold the soil on slopes. AKARPILES is mainly used to stabilized the shallow slope failure with a depth of fewer than 4 meters. These types of nails have many advantages in that they are portable in size so reduced the transportation cost, less manpower, and machinery required for working, less time required to stabilize the soil slope, and enhanced the safety of slope by minimizing the risk of slope failure.

CONCLUSION

The present paper focuses on the various researches on different types of soil nails and their effectiveness on stabilization of soil. As we know that soil nail wall performs better than conventional wall systems. The above literature review shows that innovation in soil nailing like screw nail, hollow core nail, launched nail, geonail, AKARPILES give more stability and more pullout resistance than conventional soil nails.

REFERENCES

[1] S. Saran "Engineering Aspects of Reinforced Soil", Indian Geotechnical Journal, vol. 35, no. 1, 2005.
[2] K. Premalatha, M. Muthu Kumar, and D. Mohan Babu, "ANALYSIS AND DESIGN OF NAILED SOIL WALL—A CASE STUDY", Geotide, IGC 2009.
[3] K. Tei, "A study of soil nailing in sand", Doctoral dissertation, Magdalen College, University of Oxford, 1993.
[4] FHWA (2003) Geotechnical engineering circular No. 7—soil nail walls. Report FHWA0-IF-03–017. US Department of Transportation Federal Highway Administration, Washington DC Magdalen College, University of Oxford.
[5] H. Tokhi, G. Ren, and J. Li, "Laboratory study of a new screw nail and its interaction in sand" Computers and Geotechnics, vol. 78, pp. 144–154, September 2016.
[6] S. Rawat, and A. K. Gupta, "Testing and Modelling of Screw Nailed Soil Slopes" Indian Geotechnical Journal, vol. 48, no. 1, pp. 52-71, February 2017.
[7] Xinyu Ye, Qiong Wang, Shanyong Wang, Scott Sloan, and Daichao sheng, "Performance of a compaction-grouted soil nail in laboratory tests" Acta Geotechnica, vol. 14, pp. 1049–1063, July 2018.
[8] FHWA 2006. "Hollow-Core Soil Nails: State-of-the-Practice" Unassigned, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.
[9] G. Murray, W. Okada, R. K. Barrett, L. D. Houghton, and G.P. Quickfall, "Launched Soil Nails – Theory and Practice" New Zealand Geotechnical Society, pp. 315-326, January 2006.
[10] M. Sharma, M. Samanta, and S. Sarkar, "Laboratory study on pullout capacity of helical soil nail in cohesionless soil" Canadian Geotechnical Journal, vol. 54, no. 10, pp. 1482–1495, May 2017.
[11] Y. M. Cheng, S.K. Au, A.M. Pearson, and N. Li, "An innovative Geonail system for soft ground stabilization", Soils and Foundations", vol. 53, no. 2, pp. 282-298, February 2013.
[12] Behrooz Hamedmirjafari, Jafar Bolouri Bazaz, and Saeed Abrishami. "GFRP as an alternative for steel nails, development of a model for prediction of creep displacements using experimental tests", Arabian Journal of Geosciences, vol. 13, no. 15, pp. 13:705, July 2020.
[13] Chun-Lan Lim and Chee-Ming Chan, "An Alternative Soil Nailing System for Slope Stabilization: Akarpiles", AIP Publishing, pp. 090007-1–090007-9, November 2017.

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A Critique on Wastewater Treatment with the Aid of Nanotechnology

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Abstract - These days, water resources become paucity and also surplus amount of wastewater is discharged from various industries into the environment. Various methods are used to treat wastewater to diminish the amount of pollutants. Therefore, the productive treatment of wastewater is required in emergent for resolving this problem. It is censorious to expand and execute advanced wastewater treatment technologies with greater efficiency and less capital requisite. Between various treatments, recent advanced processes in nano-material sciences have been enchanting the heed of scientists. Although, limited collective knowledge is available in this script. Nanomaterials have been the theme of active research and development worldwide in recent years. On account of an exceptional characteristics which ensued from nanoscale size, improved catalysis and adsorption properties as well as high reactivity. This context reviews the potential build-outs in nanotechnology with respect to wastewater treatment. Few studies have exposed that nanomaterials can effectively remove various pollutants in water and thus have been successfully applied in water and wastewater treatment. In this paper, the most amply studied nanomaterials, zero-valent metal nanoparticles (Ag, Fe, and Zn), metal oxide nanoparticles (TiO_2, ZnO, and iron oxides), carbon nanotubes (CNTs), and nanocomposites are conferred and spotlighted in detail for the treatment of wastewater.

Keywords: Nanotechnology, Nanomaterials, Wastewater treatment.

Introduction

Water at all times played an outstanding role in human evolution. When people first begin settling in one place and growing crops for sustenance, it was perpetually near water sources like rivers, lakes or ground water springs. Water was essential for drinking, preparing food, bathing, cleaning, irrigating crops and a variety of other tasks, so it was important to have complete access to this resource. The water sources used for supplying water were not always clean and water was treated in one way or other to improve smell, taste and clarity or to remove disease causing pathogens, throughout the recorded history. Water treatment describes those processes used to make water more acceptable for a desired end use. It may be for domestic, industrial processes, medical and many other uses. The goal of all water treatment processes is to remove existing contaminants so that the water becomes fit to use. Water treatment includes treating water before its use and treating waste water generated after use. The latter includes sewage or domestic, agriculture or industrial waste water treatment. Many methods are available for the above types of water treatment processes. All have their own merits and demerits, ease of use, economics, efficiency and end use which drive their selection.

In recent years nanotechnology has entered the sphere of water treatment processes. Many different types of nanomaterials are being evaluated and also being used in water treatment processes. Nanotechnology holds great assure in desalination, purification and waste water treatment. Nanotechnology is also being applied to the purification of water used for human consumption and in the production of ultrapure water required for certain manufacturing processes. Finally, as will be discussed below, nanotechnology has provided several applications that can be used to treat wastewater, making the recycling of water a feasible and cost effective way to address water supply shortages.

NANOTECHNOLOGY

Nanotechnology is the study of matter at atomic and molecular scale. It deals with structures size between 1 to 100nm and involves developing materials or

 ISBN: 978-93-90214-19-8

devices with this size. Substances or materials generated having nanoscale dimensions are referred to as 'nanomaterials'. There are generally two categories of nanomaterials: fullerenes and nanoparticles.

A fullerene is any molecule composed entirely of carbon, in the form of a hollow sphere, ellipsoid, or tube. Spherical fullerenes are called buckyballs. Cylindrical ones are called carbon nanotubes or buckytubes. The carbon nanotubes have a length to diameter ratio of 132,000,000:1. Have diameter of order 1nm and length upto 18cm. They exhibit extraordinary strength and unique electrical properties. They are categorized as single walled and multiwalled nanotubes.

A nanoparticle is a metallic, semiconductor or oxide particle having dimensions between 1 to100nm. They are having a large surface area, very reactive and reveal different properties compared to the bulk material of the same substance. They exhibit very interesting mechanical, magnetic, optical, chemical and other properties.

NANOTECHNOLOGY IN WATER AND WASTEWATER TREATMENT

Recent advances in nanoscale science and engineering are providing unparalleled opportunity to develop more cost effective and environmentally acceptable water purification processes. It is suggested that many of the issues involving water quality could be determined using the products resulting from the developments in nanotechnology. Development of affordable novel technologies to treat water is among the most exciting and promising features of nanotechnology. Utilization of specific nanoparticles either embedded in membranes or on other structural media that can effectively, inexpensively and rapidly render unusable water is being explored at a variety of organizations. Removal of contaminants and recycling of the water would provide significant reductions in cost, time and labour. Aquifier and groundwater remediation are also critical issues becoming more important as water supplies steadily reduce and demand continues to enlarge. Here too nanotechnology is showing promising results. Many types of nanomaterials are being evaluated and used in purification of water contaminated with toxic metal ions, radionuclides, organic and inorganic solutes, bacteria and viruses. The classes of materials being evaluated as functional materials for water purification are metal containing nanoparticles, fullerenes, zeolites and dendrimers. These have a broad range of physicochemical properties that make them predominantly attractive as separation and reactive media for water treatment.

Zeolites are micro porous, aluminosilicate minerals commonly used as commercial adsorbents. Zeolites have a porous structure that can contain a wide variety of cations such as Na^{+}, K^{+}, Ca^{2+}, $Mg^{2+}$and others. These positive ions are rather loosely held and can be exchanged for others in a contact solution. They can be acquired from natural sources or fabricated in laboratories. Synthetic zeoloites are usually made from silicon-aluminium solutions or coal fly ash and are used as sorbents or ion exchange media in cartridge or column filters. Nanoparticles of zeolites are being evaluated for the water treatment processes.

Dendrimers are repeatedly branched, roughly spherical large molecules. It is symmetric around the core and often adapts spherical three-dimension morphology. A Dendron usually contains a single chemically addressable group called the focal point. The properties of dendrimers are dominated by the functional groups on the molecular surface. Dendrimers can be considered to have three portions a core, an inner shell and an outer shell. Ideally a dendrimer can be synthesized to have different functionality in each of these portions to control properties such as solubility, thermal stability and attachment of compounds for particular applications.

Nanofilters

Membrane processes play an imperative role in water purification, since conventional water treatment techniques such as coagulation, flocculation, sedimentation, activated carbon adsorption are not always able to remove organic pollutants to prescribed specifications. Because membrane components are considered key components of advanced water purification and desalination technologies, there is a continuous search for new material and technology for membrane fabrication. In this view nanomaterials (e.g. carbon nanotubes, dendrimers) are contributing to the development of more efficient and cost effective water filtration processes. Nanofiltration is

ISBN: 978-93-90214-19-8

one of the four membrane technologies, which utilize pressure to effect separation of contaminants from water streams. The other three are microfiltration, ultrafiltration and reverse osmosis. All of these technologies utilize semi-permeable membrane that have the ability to hold back (reject) dissolved and/or suspended solids from a water stream containing these contaminants.

A defining characteristic of the nanofilter membrane is that they reject multivalent ions to a drastically greater degree than monovalent ions. This characteristic is greatly exploited in rendering hard water soft. Water softening generally involves the removal of hardness ions, specifically calcium and magnesium. Because these ions are multivalent, they are preferentially removed by nanofilter membranes. Many organisations and countries are deploying desalination units using nanofilter membranes. The particular advantage of the nanofilter membrane technology is that the nanofilter has a higher flux rate. This means that fewer membrane components are required and it operates at a lower pump pressure, thereby contribution savings in pumping costs. Additionally at nanoscale these filter membranes may be engineered with specific properties e.g. alumina nanofilms reduce fouling by providing an electropositive surface which repels many clogging agents. Similarly, nanoscale zeolite membranes are highly chemical, mechanical and temperature resistant with a large surface area and absorption capacity. Also, it has been reported that the membranes made of carbon nanotubes can be readily cleaned by ultrasonication and autoclaving and hence the problem of fouling of these membranes can be addressed to a greater extent.

Nanosorbents

Sorbents are used as separation media in water purification to remove both inorganic and organic pollutants from contaminated water. Nanoparticles have two key properties that make them chiefly striking as sorbents. On a mass basis, they have much larger surface areas than bulk particles. Nanoparticles can also be functionalized with various chemical groups to increase their affinity towards target compounds. Several research groups are exploiting the unique properties of nanoparticles to develop high capacity and selective sorbents for metal ions and anions.

Nanocrystalline zeolites have the facility to remediate water containing cationic species such as ammonium and heavy metals, as well as chemicals, such as ^{137}Cs and ^{90}Sr. These radioactive species are found in nuclear plant waste water and polluted ground water. Along with these the carbonaceous nanomaterials i.e. fullerenes, serve as high capacity and selective sorbents for organic solutes in aqueous solutions.

Nanocatalysts and redox active nanoparticles

Nanoparticles have great potential as water-purification catalysts and redox active media due their large surface areas and their size and shape dependent optical, electronic and catalytic properties. They can chemically degrade pollutants instead of moving them somewhere else, including pollutants for which existing technologies are ineffective or prohibitively expensive. TiO_2 particles are very flexible and can serve both as oxidative and reductive catalysts for organic and inorganic pollutants. It has been reported that the removal of total organic carbon from waters contaminated with organic wastes was greatly enhanced by the addition of TiO_2particles.

Nanoscalezerovalent iron (Fe^0) and bimettalic Fe^0have emerged as effective redox media for the detoxification of organic and inorganic pollutants in aqueous solutions. These nanomaterials have larger surface areas and reactivity than bulk Fe^0particles and these nanoscale Fe^0 and Fe^0/Pt^0,Fe^0/Pd^0, Fe^0/Ag^0, Fe^0/ Ni^0 and Fe^0/ Co^0 particles can reduce a variety of organic pollutants(e.g., chlorinated alkanes and alkenes, chlorinated benzenes, pesticides, organic dyes and nitro aromatics) and inorganic anions(e.g., nitrates) in aqueous solutions, to less toxic and recalcitrant byproducts.

Dendrimer encapsulated nanocatalysts (DEN's) are also being evaluated for water treatment. Dendrimernanocatalysts containing silver, palladium and platinum is reported tohave been prepared. The average sizes of nanoparticles ranges from 1.2 to 7.5nm. These DEN's have been subsequently used in reduction of 4-nitrophenol.

Another set of nanoparticles - the magnetic nanoparticles have large surface areas relative to their volume and can easily bind with chemicals. In water treatment applications, they can be used to bind with contaminants, such as, arsenic or oil and then be removed using a magnet. Some companies are commercializing such technologies and

ISBN: 978-93-90214-19-8

researchers are frequently publishing new discoveries in this area.

Bioactive Nanoparticles

A selection of strong oxidants (e.g., chlorine) is used as disinfectants for pathogens (e.g. bacteria and viruses) in water treatment. As these compounds tend to generate toxic disinfection by products such as trihalomethanes, haloacetic acids and aldehydes, alternative disinfectants are critically needed to comply with certain safe drinking water rules. Nanomaterials are providing unprecedented opportunities to develop chlorine free biocides. It has been reported that MgO nanoparticles are very effective biocides against Gram-positive and Gram-negative bacteria and bacterial spores. Because AgI and silver nanoparticles have been used as antimicrobial compounds in various biomedical products and applications, it has been reported that several investigators are evaluating use of silver nanoparticles as biocides. Silver nanoparticles have been found to be effective nanoparticles against both Gram-positive and Gram-negative bacteria including *Staphylococcus aureus, Escherichia coli, Klebsiella pneumonia* and *Pseudomonas aeruginosa.*

Nanomaterials for catalysis and photocatalysis

Metal nanoparticles and metal oxides have verified to be verygood catalysts in oxidation reactions. They exhibit a strongcatalytic activity through which contamination molecules are oxidizedforming less toxic substances, or transformed into ecologically acceptable final products. The main reasons for theseproperties of nanoparticles are:

-- very small particle size, i.e. a large surface to volume ratio

-- high reactivity directly related to nanoparticle size.

Nanocatalysts can effectively be used for chemical oxidation oforganic and inorganic pollutants in water in advanced oxidation processes (AOP). These processes are based on arrangement of highly reactive radicals that react simply with pollutantmolecules. The application of this process is often limitedbecause of the enormously high costs of providing requiredenergy (UV lamps, ozonators, ultrasonicators, etc.)

Nanomaterials for water disinfection

Besides having excellent adsorption and catalyticproperties, some nanomaterials have confirmed to havegreat antimicrobial activity as well. Such materials includechitosan, silver nanoparticles, titanium dioxide, fullerenenanoparticles, carbon nanotubes, etc. All these nanomaterialsare mild oxidants and are moderately inert in water, and aretherefore note expected to produce harmful by-products.There are several ways of applying the nanomaterials in waterdisinfection processes:

- Direct action on bacterial cells in the sense of preventingelectron passage through the membrane.
- Break through the cell membrane.
- Oxidation of some cellular components.
- Hydroxyl radicals (within the action of nanoparticles asphotocatalysts).
- The formation of dissolved metal ions that can cause damageto cellular components.

Nanomaterials for adsorption of pollutants

Nanoparticles own two central characteristics thatmake them very good adsorbents. These are the large specific surface of nanomaterials and surface multifunctionality or the ability to easily chemically react and bind to different adjacent atoms and molecules. These characteristics makenanoparticles not only effective adsorbents for diversecontaminants in wastewater but also allow for long-termstability, as this also results in adsorbent degradation with theaddition of catalytic properties of nanoparticles and improvesthe adsorption efficiency.

Compared to the best known such material - activated carbon- carbon nanotubes possess approximately the same largespecific surface, but their great advantage lies in the structureof nanomaterials and a much better arrangement of carbonatoms. In addition, nanomaterials possess unique mechanical,electrical, chemical, and optical and many other characteristicsthat allow them to have much better adsorption propertiesfor some contaminants.

Nanoscalezerovalent iron (nZVI)

Remediation of wastewater using nanotechnology is alsogaining a better interest. Compared to conventional materialsand technologies, nanoparticles can provide great materialand energy

ISBN: 978-93-90214-19-8

savings due to their prominent properties.Their nanostructure allows them to act as colloids, and so they can effortlessly be injected into the soil and associatedwith contamination, regardless of location and depth. Keycharacteristics that nanoparticles must have in terms ofremediation of contaminated groundwater are:

- High reactivity with contaminants
- High mobility within porous medium
- Appropriate life span
- Negligible harmful effects.

CONCLUSION

There is a devastating demand for new technologies that can perk up the cleanliness and consistency of water, whether it is for human consumption or for agricultural or industrial applications. As noted, there are several promising commercial applications of nanotechnology in the process of being developed and brought to market. However, before these technologies can make the leap from the laboratory to the mass market, they will need to clear the hurdles of public acceptance and economic feasibility. Many of these applications are still in their infancy and will require further testing to prove their reliability. Furthermore, implementing many of these technologies will require additional capital investment by existing water treatment centres to upgrade equipment and train personnel. However, though the proponents of nanotechnology face a challenge in convincing private and public entities to incur the up-front costs of adopting these new water purification technologies, nanotechnology holds out the promise of long-term benefits in the form of decreased costs of purifying the world's water supplies and the enormous savings that would accompany reliable access to potable water in those areas of the world that currently suffer from lack of adequate drinking water and basic sanitation services.

REFERENCES

1. A product manufactured by American Biotechnology Inc. (Baltimore, MD), under the name ASAP.
2. Chen,Y., L. Wang, S. Jiang and H.J. Yu, 2003. Study on novel antibacterial polymer materials preparation of zeolite antibacterial agents and antibacterial polymer composite and their antibacterial properties. J. Polymer. Mater., 20: 279-284.
3. Chohan, Z.H., C.T. Suparna and A. Scozzafava, 2004. Metalloantibiotics: Synthesis and antibacterial activity of cobalt (II), nickel (II) and zink (II) complex of kefzol. J. Enz. Inh. Med. Chem., 19: 79-84.
4. Cik, G., H. Bujdakova, F. Sersen, 2001. Study of fungicidal and antibacterial effect of the Cu (II)complexes of thiophene oligomers synthesized in ZSM-5 zeolite channels. Chemosphere, 44: 313-319.
5. Colvin, V.L., 2003. The potential environmental impact of engineered nanomaterials. Nature Biotech., 10: 1166-1170.
6. David Grenshaw(2009).Nanotechnology for clean water treatment: Facts and figures. 6-May-2009. URL:www.SciDirect.net.
7. Dendrimers. URL: en.wikipedia.org/wiki/Dendrimers.
8. Diallo, M.S., S. Christie, P. Swaminathan, J.H. Johnson and W.A. Goddard, 2005. Dendrimer enhanced ultra-filtration recovery of Cu (II) from aqueous solutions using Gx-NH2-PAMAM dendrimers with ethylene diamine core. Environ. Sci. Technol., 39: 1366-1377.
9. Droste, R.L., 1997. Theory and practice of water and wastewater treatment. New York: Wiley (Book).
10. Feng, Q.L., J. Wu, G.Q. Chen, F.Z. Cui, T.N. Kim and J.O. Kim, 2000. A mechanistic study of the antibacterial effect of silver ions on Escherichia coli and Staphylococcus aureus. J. Biomed. Mater Res., 52: 662-668.
11. Frechet, J.M.J. and D.A. Tomalia, 2001. Dendrimers and other dendritic polymers. New York: Wiley and Sons.
12. Fullerene. URL: en.wikipedia.org/wiki/Fullerene.
13. Gupta, S., J. Behari and K. Kesari, 2006. Low frequency ultrasonic treatment of sludge. Asian J. Wat, Envi and Pollu., 3-2: 101-105.
14. Ichinose, N., Y. Ozaki and S. Kashu, 1992. Superfine particle technology. Springer, London, (Book). 18. Stoimenov, P.K., R.L. Klinger, G.L. Marchin and K.J. Klabunde, 2002. Metal oxide nanoparticles as bactericidal agents. Langmuir, 18: 6679-6686.
15. Ishibashi, K.I., 2000. Generation and deactivation processes of super oxide formed on TiO2 film illuminated by very weak UV light in air or water. J. Phys. Chem. B, 104: 4934-4938.

16. Islam, M.S., H.M. Motahar, Banu, L. Arjuman, C. Sultana and M.A. Quadir, 2003. Antibacterial and antifungal activity of mixed ligand complexes of oxovanadium (IV), titanium (III) and cadmium (II) metal ions. Oriental J. Chem., 19: 547-554.
17. John Loncto, Marlan Walker and Lynn Foster(2007). Nanotechnology in Water Industry.*Nanotechnology Law and Business,* June 2007, pp: 157-159.
18. Jung, J.Y., Y.C. Chung, H.S. Shin and D.H. Son, 2004. Enhanced ammonia nitrogen removal using consistent biological regeneration and ammonium exchange of zeolite in modified SBR process. Water Res., 38: 347-354.
19. Katherine Watlington for U.S. Environmental Protection Agency. Emerging Nanotechnologies for Site Remediation and Wastewater Treatment. August 2005, pg 35.
20. Mamadou, S.D. and N. Savage, 2005. Nanoparticles and water quality. J. Nano. Res., 7: 325-330.
21. Mclean, R.J.C., A.A. Hussain, M. Sayer, P.J. Vincent, D.J. Hughes and T.J.N. Smith, 1993. Antibacterial activity of multilayer silver copper surface-films on catheter material. Can. J. Microbiol., 39: 895-899.
22. Nair, A.S. and T. Pradeep, 2004. Reactivity of Au and Ag nanoparticles with halocarbons. Applied Nanoscience, pp: 59-63.
23. Nanotechnology. URL: en.wikipedia.org/wiki/Nanotechnology.
24. Nora Savage and Maadoe S. Diallo.(2005). Nanomaterials and water purification: Oppurtunities and challenges. *Journal of Nanoparticle Rsearch* ,2005,pp 7: 331-242.
25. Oberdörste, G., 2001. Pulmonary effects of inhaled ultrafine particles. Intl. Arch. Occup. Environ. Health, 74: 1-8.
26. Peter S. Cartwright. Nanofiltration, When it works for the whole house. URL: http://www.wcponline.com /pdf/Nano.pdf.
27. Shearer, A.E.H., J.S. Paik, D.G. Hoover, S.L. Haynie and M.J. Kelley, 2000. Potential of an antibacterial ultraviolet-irradiated nylon film. Biotech and Bioeng., 67: 141-146.
28. Stoimenov P.K., R.L. Klinger, G.L. Marchin& K.J. Klabunde, 2002. Metal oxide nanoparticles as bactericidal agents. *Langmuir 2002*, *18*, pp*6679-6686.*
29. Ulkuseven, B., A. Tavman, G. Otuk and S. Birteksoz, 2002. Antimicrobial activity of Fe-III, Cu-II, Ag-I, Zn-II and Hg-II complexes of 2-(2hydroxy-5-bromo/nitro-phenyl)-1H and 2-(2hydroxyphenyl)-5-methyl/chloro/nitro-1H benzimidazoles. Folia Microbiol. 47: 481-487.
30. US Environmental Protection Agency, 1998. Variance technology findings for contaminants regulated before 1996. EPA Opace of Water Report 815-R-98-003.
31. US Environmental Protection Agency, 1998b. Microbial and disinfection by-product rules. Federal Register, 63: 69389-69476.
32. US Environmental Protection Agency, 1999. Alternative disinfectants and oxidants guidance manual. EPA Office of Water Report 815-R-99014.
33. World Health Organization, 1996. Guidelines for drinking-water quality. Geneva: WHO, Vol: 2.
34. Zeman, L.J. and A.L. Zydney, 1996. Microfiltration and Ultra-filtration. New York: Marcel Dekker principles and applications, (Book).
35. Zeolite. URL: en.wikipedia.org/wiki/Zeolite. Zhang W.X. 2003, Nanoscale iron particles for environmental remediation. *J .Nanoport.* Res.5, pp323-332.

Cut-Off Wall- A Boon for Deep Dam Foundation Pits: A Case Study of Mangdechhu Hydro-Electric Project, Bhutan

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Abstract - Ingress of water from upstream and downstream coffer dams poses a serious risk in successful excavation of the deep dam foundation pit. It may seriously affect the construction schedule and result in excessive cost overrun along with threatening the stability of the coffer dams itself. Therefore adequately planned seepage control measures benefits both the owner and contractor in reducing the risk in terms of schedule, cost and stability. In order to restrict the seepage in dam foundation, impermeable curtains in the form of grout curtain, clay core and cut-off walls are used as barriers in the dam projects. Out of all, the cut-off wall is the most effective solution for control of ground water seepage underneath the dam. In view of this, foundation of the 22m high upstream coffer dam of Mangdechhu Hydro-Electric Project was systematically explored to arrive at a suitable seepage control measure, which was achieved by replacing the permeation grouting seepage control measure as suggested in tender drawings by a cut-off wall.

Introduction

Controlling the ground water seepage is one of the major challenges encountered during design and construction of the dam projects. The effects of the uncontrolled ground water seepage are very important for the stability of the dam and as well for seepage loss. Ground water seepage may cause catastrophic results if not addressed properly. Uncontrolled ground water seepage may also cause considerable economic problems due to water loss (Durgunoghu, et. al., 2012, Ghazavi et. al., 2004). More seriously, if the velocity of the seepage water where it emerges on the downstream is large, particles of the foundation material can be washed away by the water and thus decrease the resistance to seepages resulting in an increase in the velocity and greater erosion, ultimately causing the formation of a channel underneath the structure which may enlarge rapidly and cause the failure of the structure, namely piping phenomenon (Tanaka and Yahagi, 1956). Impermeable curtains in the form of grout curtain, clay core and cut-off walls are the well-known ground water seepage barriers used in the dam projects. Of these cut-off wall is the most effective solution for control of ground water seepage underneath the dam.

The construction technology of the cut-off wall was introduced in 1950-60 in China and since then has gone a rapid development. Cut-off wall as seepage control barrier has been successfully used the world over in dam projects in different environments and geological conditions (Bruce and Stefani, 1996, Cyganiewicz, 1998, Shadravan et. al., 2004, Simpson et. al., 2006, Amos et. al., 2007).

In Context of Indian Himalayan region the first cut-off wall for the dam project was constructed in Dhauliganga hydro-electric project. Kishanganga and Teesta-III are other dam project where it has been employed as water seepage barrier in India. In Bhutan the cut-off wall as ground water seepage control barrier has been constructed along the upstream coffer dams in Punatsangchhu-I and Mangdechhu hydroelectric electric project.

Mangdechhu Hydro-electric Project

The 720 MW Mangdechhu Hydro-Electric Project is under construction on Mangdechhu River in Central Bhutan. The project comprises of a 112m high concrete gravity dam, two underground desilting chambers, 6.5m diameter and 13.521km long head race tunnel, a 152m deep open to sky surge shaft, two pressure shafts of stepped configuration comprising four horizontal and three vertical limbs each, an underground power house and transformer hall cavern, and a 1.333km long tail race tunnel. The construction of dam involved the construction and treatment of upstream and downstream coffer dams for ensuring effective water tightness to prevent ingress of ground water into the dam pit during excavation and concreting, which was achieved by providing a grout curtain by means of permeation grouting in downstream coffer dam and cut-off wall along the upstream coffer dam.

Geology of dam area:

Stratigraphically, the dam area lies in the lower structural unit of Bhutan Himalayan sequence, which in turn is part of Central Crystalline belt of Higher Himalayan Orogen (Ganser, 1964 and 1983). The geology of the dam area is represented by the rocks of the Thimphu Gneissic Complex of Proterozoic age (Jangpangi, 1974 and 1978, Grujic et.al., 2002) and mainly comprises of granite gneiss and granite with subordinate bands of schist and traversed by granitic intrusives.

River bed geology:

The Mangdechhu River in dam area flows in S30°W direction, the average channel width is about 70m, with mean river bed at EL 1700m. The bed rock depth below river fill material (centre of river channel) varies from 40 to 65m. The river bed material comprises of boulders, cobbles, pebbles and gravels of granite, granite gneiss, pegmatite and quartzite embedded within a medium to fine grained sandy matrix. The size of boulders reaches upto 6m. Detail subsurface investigation during construction phase also revealed presence of a prominent sand horizon of undulating thickness both along and across the channel sandwiched between the coarser river bed materials. The thickness of this horizon varied between 4.5 to 12m, while its depth below river bed varies from 1 to 12m (Figure-1). The presence of the fine grained sand horizon and sand lenses was also proven during the course of the dam pit excavation where they were intercepted at various levels. The sand horizon comprised of well-rounded and well sorted fine to medium grained sand. This horizon also exhibited higher permeability values ranging from 3 X 10-3 to 10 X 10-3 cm/sec as compared to the surrounding coarser material whose permeability ranged from 1.6 X 10-3 to 5.1 X 10-3 cm/sec (Mishra et al., 2016).

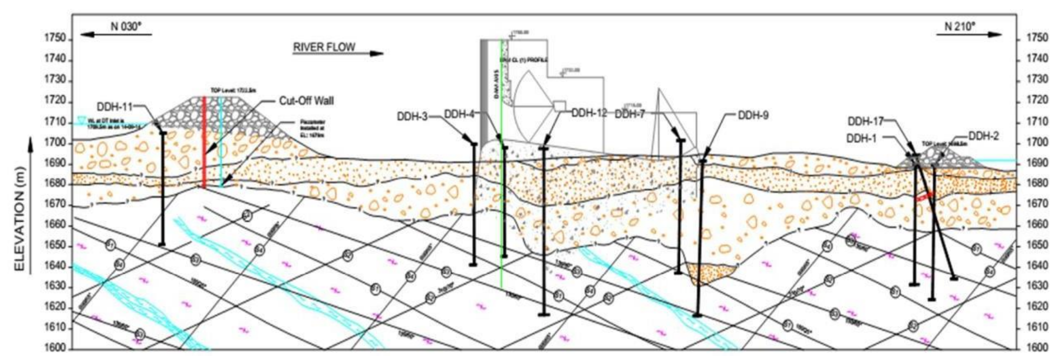

Figure-1: Geological section along river showing disposition of different horizons of river bed material.

Geotechnical evaluation of river bed material

The maximum thickness of river bed material along upstream coffer dam is 43m. The channel fill material comprised of well compacted boulder to gravel grade material in a sandy to silty matrix. Boulder size generally ranged from 0.7m to 6.0m. The sandwiched fine to medium grained sand body exhibits pinching and swelling nature and has continuity across the channel. This sand horizon is thicker towards the left bank where its thickness is 12m and gradually tapers towards the right bank where its thickness is just 1m (Figure-2).

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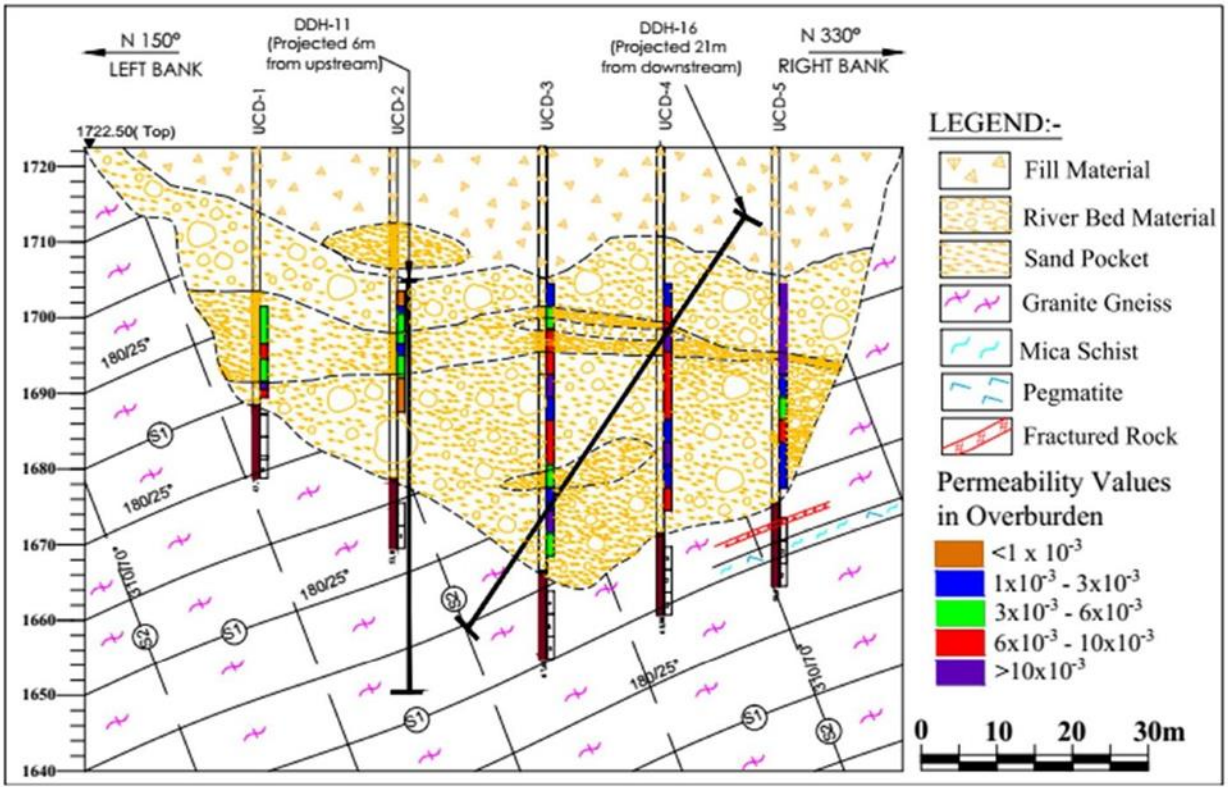

Figure-2: Geological section along upstream coffer dam.

Grain size analysis of 10 samples of this horizon in accordance to IS 2720 - part 4, (1985) revealed that the dominant constituent of the horizon is medium to fine grained sand with some silt and clay content. Percent of silt/clay content ranged from 3.43% to 17.85%. In sample no S2, S3 and S7 gravels were also present. The percentage of fine material (fine sand plus silt/clay) ranged from 61 to 100%. The particle size distribution range of the samples is tabulated in Table-1 and shown in Figure-3, while the percentage range of different grain size material is summarized in Table-2.

Table-1 Particle size distribution of various samples from sand horizon

Sample No.	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10
Gravel (%)	0.00	11.32	18.67	7.65	0.00	0.00	3.16	0.00	0.00	0.00
Coarse Sand (%)	0.41	18.25	7.37	5.10	1.57	0.20	0.75	0.00	0.39	0.00
Medium Sand (%)	7.80	9.44	4.38	1.64	0.48	1.98	0.44	0.22	0.34	0.80
Fine Sand (%)	88.36	43.13	60.94	73.97	85.41	87.42	86.11	88.85	89.14	94.29
Silt (%)	3.43	17.85	8.64	11.64	12.54	10.41	9.55	10.93	10.12	4.91
Fine Sand + Silt (%)	91.79	60.98	69.58	85.61	97.95	97.83	95.66	99.78	99.26	99.20

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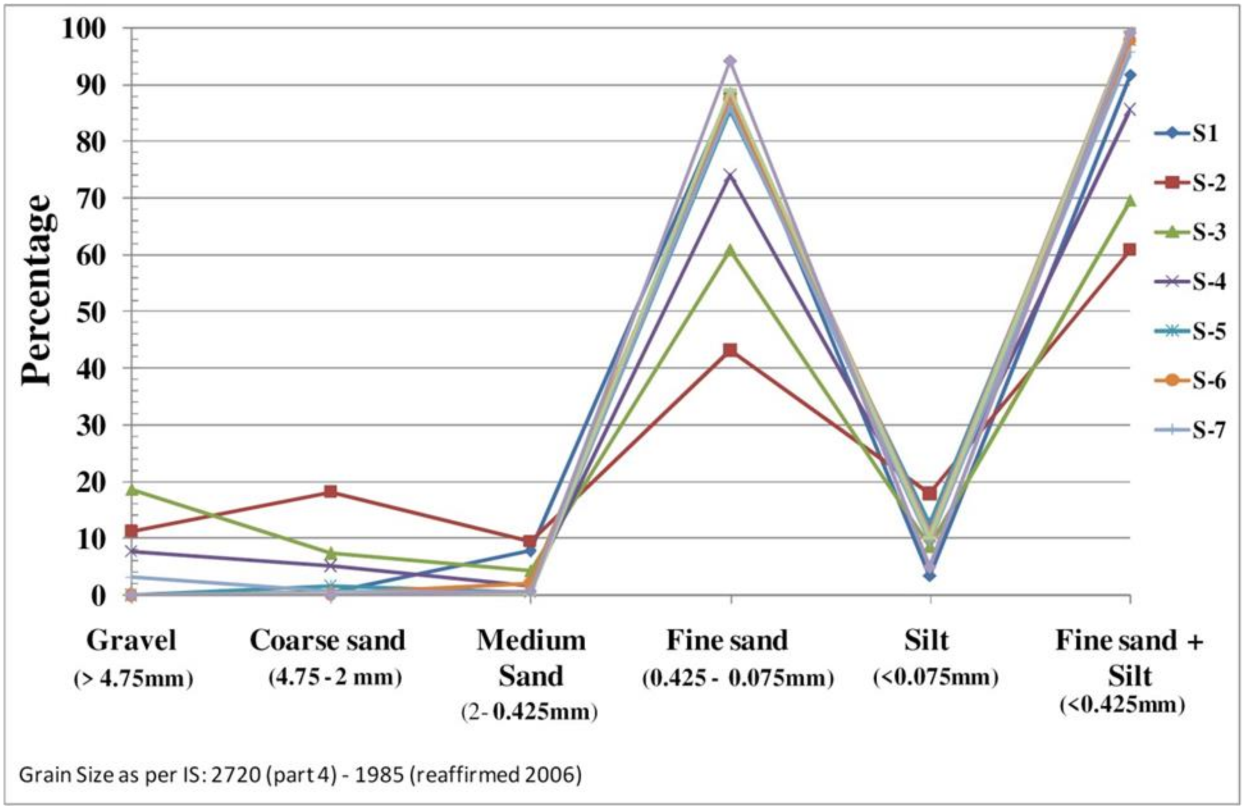

Figure-3: Graphical representation of grain size distribution of sand horizon

Table-2
Range of particle size distribution of sand horizon

Size	**Minimum (%)**	**Maximum (%)**
Gravel	0.00	18.67
Coarse Sand	0.00	18.25
Medium Sand	0.22	9.44
Fine Sand	43.13	94.29
Silt	3.43	17.85
Fine Sand + Silt	60.98	99.78

Replacement of permeation grouting by Cut-off Wall:

Based on the limited DPR stage investigation presence of fine grained sand/ silt horizon sandwiched between coarser river fill material and spanning the entire foundation area could not be inferred. As a consequence sealing of the coffer dams to arrest ingress of water into the dam pit through them was suggested by means of permeation grouting. Subsequent to the detailed investigations during construction phase presence of the sand horizon spanning along and across the foundation area was deciphered. The grain size analysis of this horizon revealed that the dominant content of the horizon is fine sand and silt which whose percentage ranges from 61 to 100% (Table-2). This fine material could not be effectively made water tight by grouting as most of the grouting materials (cement/ bentonite/ polyurethane/ polyacrylamide/ silicates/

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amonoplasts, etc.) could not penetrate through such fine material (Figure-4). In view of the impenetrability of grout in this fine material horizon it was evident that permeation grouting will not be a suitable seepage control method and failure of grout curtain against seepage during dam foundation pit excavation may entail extremely high cost of dewatering, while also having negative impact on the schedule completion of the dam pit excavation as a whole. Further in view of the high head anticipated upstream of coffer dam and higher permeability of sand horizon possibility of “piping action” which could de-stabilize the coffer dam itself, were also high. In view of this the project authority decided to provide a cut-off wall along the upstream coffer dam instead of permeation grouting to ensure effective seepage control barrier. The cut-off wall not only ensured the seepage control but also ensured the stability of the structure along with providing better working conditions and ensuring proper cleaning of the dam foundation and quality placement of rock cover concrete.

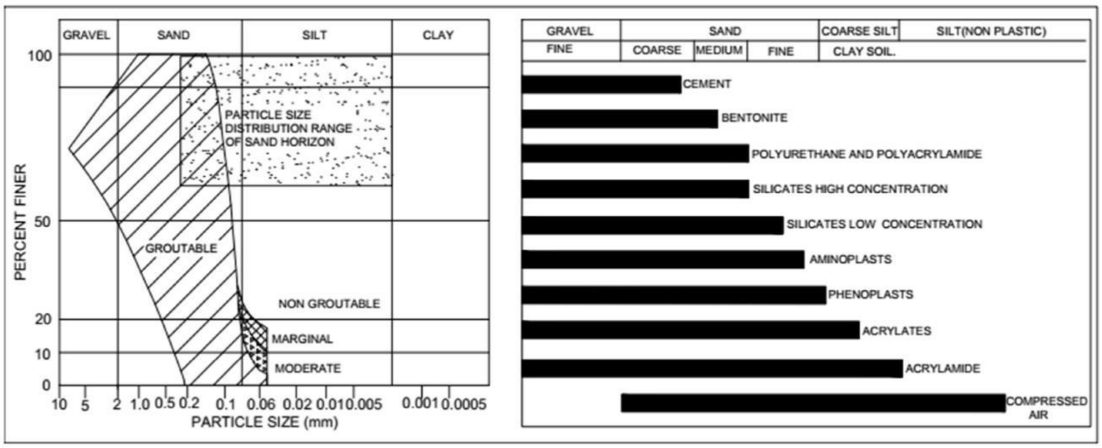

Figure-4: Groutability of various materials and penetrability of grouts through them (IS 14343:1996).

Construction of Cut-off Wall:

The 107.8m long cut-off wall at the upstream coffer dam comprised of 43 panels of 2.8m length and 1.2m width, casted to 1.2m into the bed rock below river fill material. Of 43 panels 22 were primary panels and 21 secondary. An overlap of 30cm on both sides was maintained between the primary and secondary panels (Figure-5).

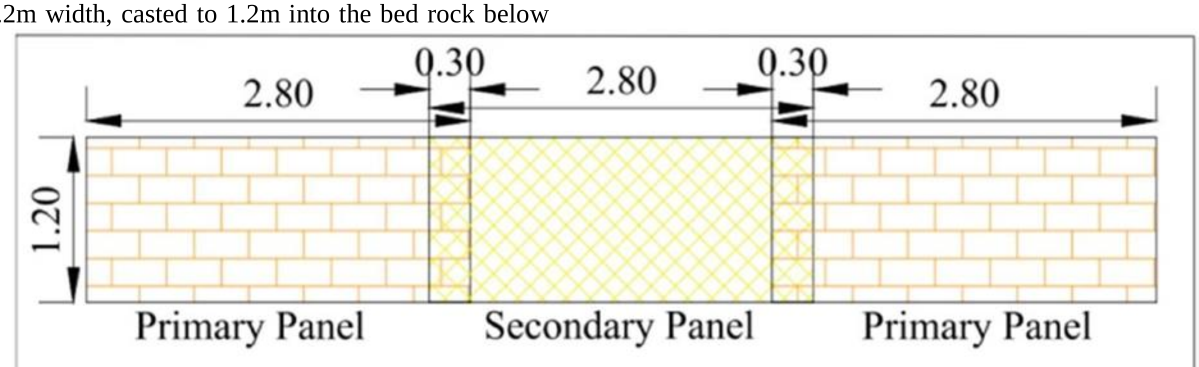

Figure-5: Panel configuration of cut-off wall showing primary and secondary panels along with overlaps

The construction of the cut-off wall was undertaken by first constructing two guide walls to the depth of 1.5m on upstream and downstream side of the proposed cut-off wall trench (Figure-5) for guiding the panels and to arrest falling of any loose material into the trench during the excavation of panel pit and placement of the plastic concrete. Thereafter treatment of the fill material of the coffer dam body and river fill material was undertaken by systematic grouting by aid of primary holes spaced 3m apart

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followed by secondary holes placed between primary holes. The grouting was undertaken in descending order in stages of 3m section depth and upto 1.2m into the bed rock, along both the guide walls.

Figure-5: Photograph showing guide walls along the panel trench

After grouting along both the guide walls the top 5 to 10m of the material between the guide walls and equal to length of one panel was removed by a grab machine, a twin cutter was then used to excavate the panel pit. Bentonite slurry was circulated through the cutters to carry the cuttings from the pit to the de-sanding plant where the rock cuttings and sand/ silt were segregated from the slurry before re-pumping it into the pit. Bentonite slurry apart from removing the excavation cuttings also provided support to the trench wall during the excavation process by the grab and the cutter. The panel pits were excavated 1.2m into the bed rock below river bed material. Large and strong boulders which could not be handled by cutter were broken by chisel. After driving panel pit 1.2m into the bed rock placement of plastic concrete was carried out. The panel excavation/ driving process was continued alternatively in all primary panels keeping 5 to 6 panels apart for plastic concrete to set properly. After placement of all 22 primary panels secondary panels were driven between primary panels, maintaining an overlap of 30cm on both sides to ensure that no gap/ void remains between two adjacent panels for ensuring effective seepage control barrier. The section of the cut-off showing panel configuration is depicted in Figure-6.

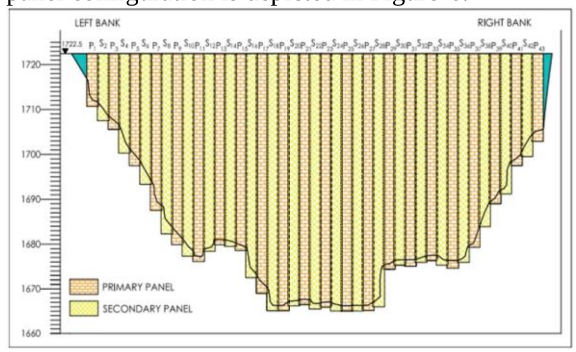

Figure-6: Cut-off wall section showing panel configuration

Efficacy of Cut-off Wall:

To monitor the efficacy of the cut-off wall, two piezometers were installed in the close vicinity of downstream side of it, with their sensor placed close to overburden- bed rock interface to monitor the pore water pressure and water head downstream of the cut-off wall. Monitoring of the water level upstream of coffer dam and piezometer reading was undertaken on daily basis. From pore water pressure recorded by piezometer water head was calculated and compared with that observed upstream of the coffer dam (Figure-7a and 7b). From the variation observed in the recorded water level upstream of coffer dam and that interpreted from piezometer observations it was inferred that the prevailing water head upstream of coffer dam was not being communicated to the downstream of cut-off wall, indicating its high efficacy in controlling seepages. Further during the excavation of the dam pit for foundation, it was observed that seepages into it were negligible and only two pumps, working intermittently were sufficient to provide dry working conditions.

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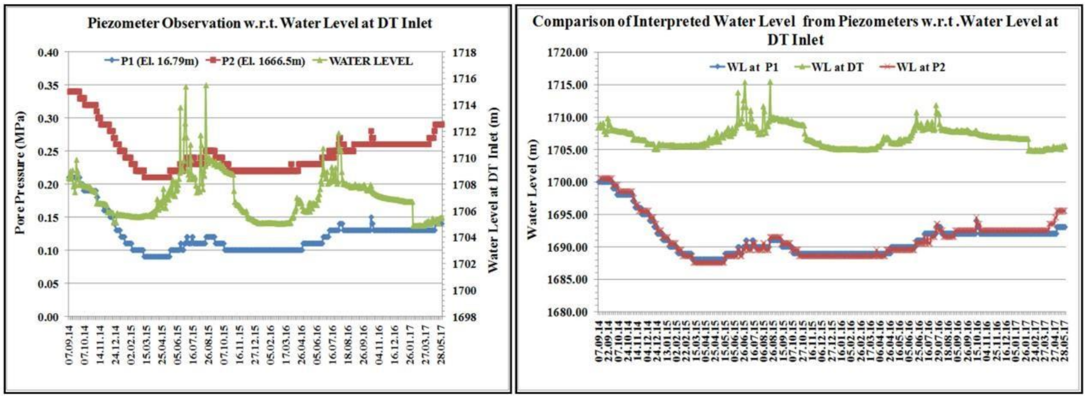

Figure-7 (a) Pore pressure observation (b) comparisons of interpreted water level with recorded water level upstream of coffer dam.

Conclusion

Seepage quantity underneath and through the body of coffer dam has an important bearing on the construction schedule, financial implication and quality of the construction in any dam project. Even with numerical modeling techniques it is difficult to model the heterogeneous matrix of the river bed material to work out the quantum of seepage. The usual mathematical modeling followed by designer is based on homogeneous matrix which does not represent the true matrix and thereby the quantity of the seepage is always either overestimated or underestimated. The cut-off wall is the most effective solution for control of ground water seepage underneath the dam. The Mangdechhu Hydroelectric Project Authority (MHPA) carefully tackled this problem right in the beginning and saved precious time by ensuring scheduled excavation of the dam foundation pit. With cut-off wall in place along the upstream coffer dam the excavation of almost 60m deep foundation pit was done without and seepage problems. Apart from this the quality of foundation excavation, cleaning and placement of first lift of concrete in dam foundation was of excellent quality, which under seepage conditions is difficult to achieve.

References:

1. Durgunoglu, H. T., Ikiz, S., Eser, S., Akcakal, O., Sutman, M., 2012, "A case study – installation of cut-off wall in Seyrantepe dam project", Proceedings of the fourth international conference on grouting and deep mixing.
2. Ghazavi, M., Safarzadeh, Z., Hashemolhoseini., H., 2004, "Response of plastic concrete cut-off walls in earth dams to seismic loading using finite element methods", Proceedings of 13th world conference on earthquake engineering Vancouver, B.C., Canada.
3. Tanaka, H., Yahagi, F., 1956, "Some considerations on the cut-off wall length in the pervious foundation", Le Bulletin d'Information de l'Association International d'Hydrologie Scientifique, Hydrological Science Journal.
4. Bruce, D.A., Stefani, S., 1996, "Rehabilitation of Beaver dam: a major seepage cut-off wall", Ground Engineering, Vol. 29, No. 5, pp 40 – 45.
5. Cyganiewicz, J.M., 1988, "Construction of cut-off wall at Fontenelle dam", Proceedings of 16th ICOLD conference, San Francisco, CA, Vol. 5, pp. 227 – 230.
6. Amos, P. A., Bruce, D. A., Lucchi, M., Newson, T., Wharmby, N., 2007, "Design and construction of seepage cut-off walls under a concrete dam in New Zealand with full reservoir", Annual conference of the association of state dam safety officials, Vol. 2, pp 676 – 692.
7. Shadravan, B., Mirghasemi, A. A., Pakzad, M., 2004, "Karkheh storage dam cutoff wall analysis and design", Proceedings: Fifth international conference on case histories in geotechnical engineering, New York.
8. Simpson, D.E., Phipps, M., Ressi, A.L., 2006, "Constructing a cutoff wall in front of Walter F. George dam in 100 feet of water", Hydro Review, Vol. 25, No. 1 HCL Publications.

9. Ganser, A., 1964, "The Geology of the Himalayas", Wiley Interscience, New York, p. 289.
10. Ganser, A., 1983, "The Geology of the Bhutan Himalayas", Birkhavser, Basel, p. 181.
11. Jangpangi, B.S., 1974, "Stratigraphy and tectonics of parts of Eastern Bhutan",
12. Himalayan Geology, Vol. 4, pp. 117 – 136.
13. Jangpangi, B.S., 1978, "Stratigraphy and structure of Bhutan Himalayas", Saklani, P.W.S., ed., Tectonic Geology of Himalaya, Todays' and Tomorrows' Publications, New Delhi, 221 – 292.
14. Grujic, D., Holister, L.S., Randall, R.P., 2002, "Himalayan metamorphic sequence as an orogenic channel: Insight from Bhutan", Earth and Planetary Sciences Letters, Vol. 198, pp. 1777 – 191.
15. Mishra, A. K., Chaudhary, R. K., Punetha, P., Lahkar, K., Ahmed, I., 2016, "Case study on upstream coffer dam foundation condition of Mangdechhu hydroelectric project, Bhutan", Proceedings international conference on dams and underground structures: latest technology, planning, design and construction, New Delhi.
16. IS: 2720 (Part – 4), 1985 (Reaffirmed 2006), "Indian Standard method of test for soils, part – 4, Grain size analysis (second revision)", Bureau of Indian Standards, New Delhi, pp. 1 – 38.
17. IS: 14343, 1985 (Reaffirmed 2001), "Indian Standard – Choice of grouting materials for alluvial grouting – Guidelines", Bureau of Indian Standards, New Delhi, pp. 1 – 9.

ISBN: 978-93-90214-19-8

Study on Replacement of Conventional Concrete Materials with Waste Materials – A Review

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Abstract :- Concrete is more produced than any other man-made material all over the world. It is the second most-consumed material in the world after water and in the future, the demand for concrete is going to be increasing more. Concrete is made up of materials such as cement, fine aggregate, coarse aggregate, and water. Most of the materials used in concrete production are generated from natural resources and the resources are limited. Some materials used in concrete causes environmental pollution during their production. It is much necessary to protect the environment and save natural resources. This problem can be solved by replacement of concrete materials with different materials. The amount and type of waste materials increasing because of the increase in population day by day. These waste materials cause disposal crises and contribute to environmental problems. The use of waste material in concrete is done for the safe and economical disposal of waste materials. This paper discusses the idea of partial replacement of cement with sugar cane bagasse ash and partial replacement of sand with quarry sand in the concrete. The use of waste materials as a replacement in concrete saves natural resources, dumping space, and maintains a clean environment. From the literature, it is observed that 10% to 20% of cement can be replaced by sugarcane bagasse ash and 40% to 50% of sand can be replaced by quarry sand in the concrete.

Keywords :- ***Bagasse ash, Natural resources, Quarry sand, Waste materia***

I. INTRODUCTION

The construction industry is evolving day by day. Due to infrastructural growth, Huge quantities of construction materials are required in developing countries. As concrete is the second most-consumed substance on the earth after water. So cement, sand, and aggregate are the basic need for any construction project. But most of the materials used in concrete production are generated from natural resources like natural sand obtained from rivers. Also during the production of cement, there is a production of carbon dioxide which is harmful to the environment. So it is necessary to preserve natural resources and protect the environment. Our focus as civil engineers should be towards maintaining the balance between construction and a sustainable environment. To do so there is a need to find an alternative for the traditional materials used in concrete.

Every year huge amount of waste is produced in India. There are several types of waste from industry, agriculture, domestic, demolition, etc. The disposal of waste is a serious problem. As it requires huge places to store like dumping yards and also it affects the environment. To deal with both problems a sustainable concept is introduced in which the conventional concrete materials are partially replaced by waste materials.

Sugarcane is one of the major crops grown in many countries all over the world. In India only over 300 million tons/ year of sugarcane is produced [1]. After extraction of all sugar from sugarcane, large fibrous excess is obtained known as bagasse [2]. Bagasse is a by-product from sugar industries that is burnt to generate the power required for different activities like it is used as fuel to heat the boilers in the factory. The burning of bagasse leaves bagasse as a waste [3]. Sugarcane bagasse ash contains silica and aluminum ion, which is pozzolanic in nature. The minimum silica, and iron oxide content is 70%, and SiO3 should be less than 4% For natural pozzolans. Bagasse ash fulfills these requirements so the ash behaves as pozzolanic material [4]. To study pozzolanic activity and their suitability as binders few studies have been carried out on the ashes obtained directly from the industries. It is used in concrete without adverse effects on concrete durability [5]. Thus it is possible to use sugarcane bagasse ash as a replacement material for the cement to reduce the cost and improve the quality of concrete [6]. So the SCBA is an effective alternative for partial replacement of cement.

The aggregates are extracted from quarries by using various methods and there are remains of the rocks in the form of fine dust after the extraction of aggregates. This fine dust is generally known as quarry dust or quarry sand [7]. Quarry sand, is a by-product release from the cutting and crushing process of stone it becomes useless material and considered as a waste [8]. Quarry sand has a particle size distribution close to that of sand [7]. Also, the specific gravity of sand and quarry dust almost the same[9]. Quarry sand does not contain organic impurities or silt and can be produced as per required fineness and to meet the desired gradation [10]. It is also found that utilization of quarry sand as fine aggregates in concrete provides sufficient workability and also the required strength. The utilization of quarry sand as a replacement not only relieves the pressure on sand but also reduces the need for the dumping of quarry sand which was considered a waste product in the quarries [7]. So the quarry sand is an effective alternative for the partial replacement of sand.

II. PHYSICAL PROPERTIES

Table 1 – Physical properties of materials

Materials	Properties	Values	Reference
Cement	Fineness	7% (< 15)	[1], [11]
	Specific gravity	3.1 – 3.15	[1], [3], [11]
	Density (kg/m3)	3100 - 3150	[1], [3], [12], [13]
Fine aggregate	Fineness modulus	2.4 – 3.5	[1], [10], [11], [13], [14], [15]
	Specific gravity	2.46 – 2.7	[1], [7], [9], [10], [11], [12], [13], [14]
	Density (kg/m3)	2460 - 2700	[1], [7], [9], [10], [11], [12], [13], [14]
	Bulk density (kg/m3)	1428 - 1630	[1], [9], [14]
Coarse aggregate	Fineness modulus	6.86 – 7.17	[1], [11]
	Specific gravity	2.64 – 2.83	[1], [11], [12], [13]
	Density (kg/m3)	2640 - 2830	[1], [11], [12], [13]
	Bulk density (kg/m3)	1363 - 1610	[1]
Sugarcane bagasse ash	Fineness modulus	2.12	[1]
	Specific gravity	1.25 – 2.65	[1], [3], [11], [12]
	Density (kg/m3)	1250 - 2650	[1], [3], [11], [12]
Quarry sand	Fineness modulus	2 - 3	[14], [15]
	Specific gravity	2.5 – 2.8	[7], [14], [15]
	Density (kg/m3)	2500 - 2800	[7], [9], [14]

III. CHEMICAL COMPOSITION

Table 2 – Chemical composition of SCBA

Chemical Composition of Sugarcane Bagasse Ash		
Component	Mass %	Reference
Silicon dioxide (SiO_2)	62% - 71%	[1], [2], [3], [6], [13], [16]
Aluminum oxide (Al_2O_3)	1.9% - 8.55%	[1], [2], [3], [6]
Ferric oxide (Fe_2O_3)	1.22% - 6.98%	[1], [2], [3], [6]
Calcium oxide (CaO)	1.28% - 11.8%	[1], [2], [3], [6], [13], [16]
Potassium oxide (K_2O)	1.77% - 3.53%	[1], [3], [6]
Magnesium oxide (MgO)	0.3% - 2.83%	[1], [2], [3], [13], [16]

Sulphur trioxide (SO3)	0.56% - 1.48%	[1], [3], [13], [16]
Loss of Ignition	0.42% - 4.73%	[1], [3], [6], [13], [16]

Table 3 – Chemical composition of quarry sand

Chemical Composition of Quarry Sand		
Component	Mass %	Reference
Silicon dioxide (SiO2)	62.48%	[9], [17]
Aluminum oxide (Al2O3)	18.72%	[9], [17]
Ferric oxide (Fe2O3)	6.54%	[9], [17]
Calcium oxide (CaO)	4.83%	[9], [17]
Magnesium oxide (MgO)	2.56%	[9], [17]
Sodium oxide (Na2O)	Nil	[9], [17]
Potassium oxide (K2O)	3.18%	[9], [17]
Titanium dioxide (TiO2)	1.21%	[9], [17]
Loss of Ignition	0.48%	[9], [17]

IV. TEST CONDUCTED

Partial replacement of cement by SCBA and partial replacement of sand by quarry sand gives higher value of compressive strength than normal concrete the % of replacement up to which the concrete gives good compressive strength is given in table 4.

Table 4 – Compressive Strength

Compressive strength		
Description	Replacement %	Reference
Partial replacement of cement by SCBA in concrete. Replacement percentage that gives good compressive strength than normal concrete.	10%	[1], [3], [4], [5], [6], [11]
	15%	[18], [19]
	20%	[4]
Partial replacement of sand by quarry sand. Replacement percentage that gives good compressive strength than normal concrete.	40%	[8], [15]
	50%	[7], [10], [14], [17]

Partial replacement of cement by SCBA and partial replacement of sand by quarry sand gives higher value of split tensile strength than normal concrete the % of replacement up to which the concrete gives good split tensile strength is given in table 5.

Table 5 – Split tensile strength

Split tensile strength		
Description	Replacement %	Reference
Partial replacement of cement by SCBA in concrete. Replacement percentage that gives good split tensile strength than normal concrete.	10%	[1], [4], [5], [6], [19]
	20%	[4]

ISBN: 978-93-90214-19-8

Partial replacement of sand by quarry sand. Replacement percentage that gives good split tensile strength than normal concrete	40%	[15]

V. CONCLUSION

From the literature, it is concluded that the partial replacement of cement by sugar cane bagasse ash and partial replacement of sand by quarry sand is possible.

1. By the addition of SCBA concrete becomes more durable Partial replacement of cement by SCBA increases the workability of fresh concrete and the requirement of a superplasticizer is not needed. It is also concluded that 10% to 20% cement can be partially replaced by SCBA.
2. The use of quarry dust in concrete is beneficial such as the useful disposal of a byproduct, reduction of river sand consumption, and increased strength of concrete. It is concluded that 40% to 50% sand can be partially replaced by quarry sand.

VI. REFERENCES

[1] Prashant O Modania , M R Vyawahare, "Utilization of Bagasse Ash as a Partial Replacement of Fine Aggregate in Concrete" ,Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University International Conference on Engineering (NUiCONE 2012).

[2] Brijendra Pratap, Abhishek Kushwaha, Satya Veer Singh, "A review paper on replacement of Cement with Sugarcane Bagasse Ash", Intl J Engg. Sci Adv Research Dec. 2017.

[3] G. Nithin Kumar Reddy, G. Harsha Vardhan, S. Vijaya Bhaskar Reddy, "Partial Replacement of Cement in Concrete with Sugarcane Bagasse Ash and its Behaviour in Aggressive Environments", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).

[4] Mrityunjay Kumar, Shivani Singh Dhriyan, "Review on Effect of Baggase ash on Strength of Concrete", International Journal of Engineering Research & Technology (IJERT), Vol. 7 Issue 01, January-2018.

[5] D. Dinesh Kumar, A. Ayyappan, S.Dhivagar, B.Dineshkumar, P.Marimuthu, V.Prasanth, "Experimental Investigation on Partial Replacement of Cement by Using Sugarcane Bagasse Ash" International Journal of Emerging Technologies in Engineering Research (IJETER) Volume 6, Issue 4, April (2018).

[6] R.Srinivasan, K.Sathiya "Experimental Study on Bagasse Ash in Concrete" International Journal for Service Learning in Engineering, Vol. 5, No. 2, Fall 2010.

[7] Vishal Agrawal, Pankil Sha, Armaan Gupta and Rahul Shah, "The Utilization of Quarry Dust as Fine Aggregates in Concrete", ICRISET2017. International Conference on Research and Innovations in Science, Engineering &Technology, Volume 1, 2017.

[8] K Shyam Prakash and Dr Ch Hanumantha Rao, "Strength Characteristics of Quarry Dust in Replacement of Sand", ICMAEM-2017.

[9] Chandana Sukesh, Katakam Bala Krishna, P.Sri Lakshmi Sai Teja, S.Kanakambara Rao, "Partial Replacement of Sand with Quarry Dust in Concrete" May 2013.

[10] Sumit L. Chauhan, Raju A.Bondre, "Partial Replacement of Sand by Quarry Dust in Concrete", International Journal of Scientific and Research Publications, Volume 5, Issue 7, July 2015.

[11] Lathamaheswari, R., Kalaiyarasan, V and Mohankumar, "Study on Bagasse ash as partial replacement of cement in concrete", International Journal of Engineering Research and Development Volume 13, Issue 1 (January 2017).

[12] D. Neeraja, S. Jagan, Satheesh Kumar and P. G. Mohan, "Experimental Study on Strength Properties of Concrete by Partial Replacement of Cement With Sugarcane Bagasse Ash", Nature Environment and Pollution Technology An International Quarterly Scientific Journal, Vol. 13 No. 3 pp. 629-631, 2014.

[13] Pallavi S. Kumbhare, Shifa Tanwar, Yogesh Thosar, Yash Dudhe, Gaurav Rudrakar, Krushna Teware, "Partial Replacement of Cement In Concrete With Sugarcane Bagasse Ash", International Journal of Innovations in Engineering and Science, Vol. 4, No.4, 2019.

[14] G.Balamuruga, Dr.P.Perumal, "Use of Quarry Dust to Replace Sand in Concrete – An Experimental

Study”, International Journal of Scientific and Research Publications, Volume 3, Issue 12, December 2013.

[15]Biswaprakash Das and Mahendra Gattu, “Study on Performance of Quarry Dust as Fine Aggregate in Concrete”, International Conference on Advances in Construction Materials and Structures (ACMS-2018) IIT Roorkee, Roorkee, Uttarakhand, India, March 7-8, 2018.

[16]Rahul R. Patle, Amit R. Nishad, Ariba Hamidi, Mangesh Urade, “Replacement of Cement by Bagasse Ash with Admixture”, International Journal of Science and Research (IJSR), Volume 7 Issue 4, April 2018.

[17]Nur Jannah Abdul Hamid, Aeslina Abdul Kadir, Nor Amani Filzah Mohd Kamil, Mohd Ikhmal Haqeem Hassan, “Overview on the Utilization of Quarry Dust as a Replacement Material in Construction Industry”, International Journal of Integrated Engineering, Special Issue 2018: Civil & Environmental Engineering, Vol. 10 No. 2 (2018) p. 112-117.

[18]Pratheba.S, Deepeka.K, Kanimozhi.A, Malathi.J, Nandhini.J, “An Experimental Study on Bagasse Ash as Partial Replacement for Cement in Concrete”, International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 03 | Mar-2018.

[19]Pragalbha Khare, Mohd. Afaque Khan, Neeti Mishra, “Partial Replacement of Cement with Sugarcane Bagasse Ash in Concrete : A Review”, International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 04 | Apr-2018.

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Torsional Parameters of Completely Over-Reinforced RC Beams with Ferrocement "U" Wraps at Cracking Stage

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Abstract - Structural failure takes place when induced stresses are more than the ultimate strength of the material in the structure. Structural engineers prefer cracking strength for design purpose rather than the ultimate strength. Structural engineers are in opinion to retrofit the deficient structure rather than demolition. For present era, FRP may be one of the best suited wrapping material for developed countries. On the other hand, ferrocement is a better substitute for FRP considering cost into account for developing countries. Here an attempt is made to calculate the torsional parameters such as torque, twist and stiffness at cracking stage of completely over reinforced beams with ferrocement "U" wrap. Determination of strength involves two methods. One is experimental, which is a destructive one and most reliable. The other one is development of models. Both experimental and analytical model was developed to evaluate the torsional parameters. As the above two methods are not providing quick solution, rather than the first one is based on destruction of prototype structure while second one needs programming for evaluation of strength. Other methods such as soft computing methods have been employed. Two methods MARS and WASPAS are employed here to compute the torsional parameters of "U" wrapped beams. These two methods provide quick solutions to estimate the torque, twist and stiffness at cracking stage. Predicted values by these methods are within acceptable limits.

Cracking torque of completely over reinforced "U" wrap beam with five layers with M35 concrete increases by 6.54% over its plain "U" wrap beam. The same was found to be increasing by 59.84% with respect to plain beam without any wrap. In cracking twist, no such remarkable changes were observed. Stiffness at cracking torque of completely over reinforced "U" wrap beam with five layers with M35 concrete increases by 12.76 % over its plain "U" wrap beam. Results from soft computing methods are well within acceptable limits.

Keywords: Ferrocement: U wrap: torque: twist: MARS: WASPAS

Introduction

For structural elements, calamities and disasters by human beings are the major threats. In some cases updated codal provisions and age factors compel the structures to be retrofitted rather than demolished for a sustainable practice of design. Upgradation is a bare need when a structure is found deficient to resist the induced forces or incapable to meet the updated codal requirements. Fiber reinforced polymer (FRP) "U" wrap is a common technique of upgradation of strength of beams with extension of flanges. FRP retrofitting is pricey and requires trained workmanship for application. For developing countries ferrocement wrap is a better solution over FRP. Dong et al., 2018 and Tahir et al. 2018 noticed appreciable strength increase by wrapping with FRP. Wrapping strategy is a function of type of wrapping (Karayannis et al., 2008). FRP wrapping also have the ability to change the mode of failure (Isleem et al., 2018). As torsion induces shear, it is better to wrap the full beam on all four sides (Yasmeen, 2020). (Chalioris, 2008). This may not be practicable in many cases for which "U" wrap is the alternative one. Cost of material and application procedure of FRP made it more popular in high economic group of people or areas (Deifalla, 2015). In the contrast, ferrocement wrapping has the capacity to increase the strength as reported from the works of (Li et al., 2013). Comparing with cost and strength, ferrocement can be utilized as a wrapping material in place of FRP. The properties like strength in flexure, compression and tension also low permeability of ferrocement (ACI Committee 549,1979) makes it a better substitute of FRP. In many cases as wrap on all sides may not be feasible, in that case “U-wrap” is a better choice. Smaller diameter wires in two perpendicular directions with mortar matrix on both sides of mesh are the constituent material of ferrocement. Evenly distributed higher percentage of reinforcement with lower diameter bars makes ferrocement material to resist higher strain. Micro crack arresting nature of ferrocement structure has been reported in works of (Shannag and Mourad, 2012). “U” shaped stirrups enhances the strength and stiffness of beams (Chalioris et al., 2014). All these literature have enough evidence of enhancement of strength and stiffness of “U” wrap.

1.1. Significance of Present Study

Induced shear due torsion can be resisted in a better way when wrapped on all four sides. “U” type is a better choice when wrapping all four sides are not practicable (Behera et al., 2018 GCEK). Beams with torsionally over reinforced in core provides higher strength and stiffness than other type of beams. Torsional parameters such as torque and twist at ultimate stage by experimental and analytical method were presented by the author (Behera 2014). It has been observed that for predication of torque, twist or stiffness at cracking stage, no such equations are derived. The presented parameters are from experimental and analytical method. The experimental work is destruction of proto-type structures and time dependent process. Analytical method is tedious and requires computational methods. This challenge inspired to find a solution to predict torque, twist and stiffness at cracking stage with easy method. Here, with the help of soft computing, solution is found out.

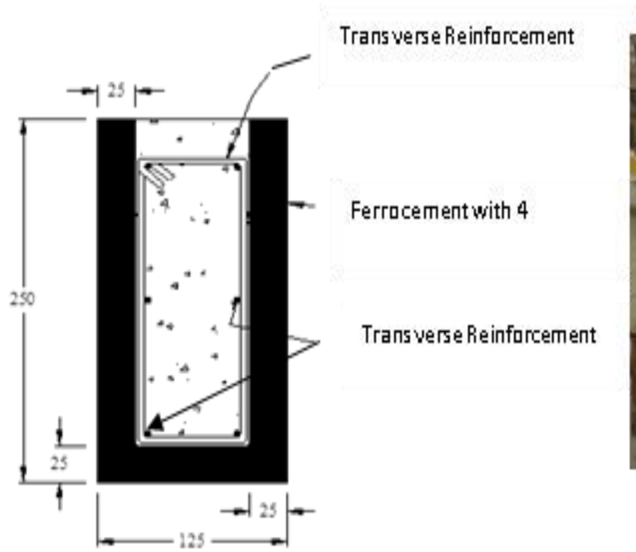
2.1 Experimental Program

Beams, torsionally over reinforced in all directions were considered in this investigation. Beams tested by this author during his doctoral program were taken into consideration. Dimension of the beams were 125 mm wide, 250 mm depth and of length 2000 mm. Table-1 and Fig.1 provide details of the beams with material properties. 25 mm ferrocement wrap with core concrete of 75 mm makes the total width 125 mm. With consideration of aspect ratio 2, the depth was fixed to 250mm.Total six beams were analyzed in this investigation. The beams were designated with alphabets and numeric. First alphabet P represents plain beam and C represents completely over reinforced beams. Numeric 3, 4 and 5 represents number of mesh layers on the ferrocement wrap. All the beams were cast with M35 grade concrete and M40 grade mortar on ferrocement face. After setting of ferrocement wrap, concrete was filled in core portion (75 mm X 225 mm) then the core concrete was cast with core reinforcement. Torsional test is done by torsion test rig. This is reported in Figure 1.

Table 1: Beam designation and material properties

S.N	Designation	Compressive strength Ferrocement matrix (MPa)	Compressive strength Concrete (MPa)	Longitudinal Steel		Transverse Rein.	
				ϕ (dia in mm), nos.	Yield Strength (MPa)	ϕ (dia in mm , Spacing mm	Yield Strength (MPa)
1	P3	40	35	“-“	“-“	“-“	“-“
2	P4	40	35	“-“	“-“	“-“	“-“
3	P5	40	35	“-“	“-“	“-“	“-“
4	C3	40	35	12 , 4	440	8, 100	465
5	C4	40	35	12 , 4	440	8, 100	465
6	C5	55	60	12 , 4	440	8, 100	“-“

ISBN: 978-93-90214-19-8



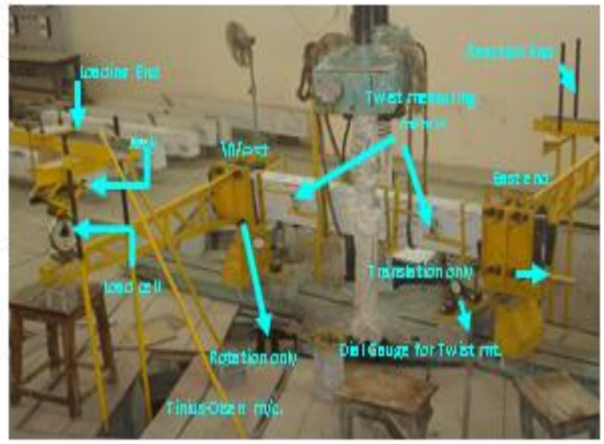


Figure 1: Beam cross section and torsion

2.2 Analytical Model

Determination any parameter requires the experimental investigation. The process involves complete destruction of proto type material and time dependent, but unavoidable. It is basis for validation of results obtained by other methods. Analytical model using softened truss theory and applying modifications in material properties was developed by author which was fully covered Behera et al. (2014 & 2014b).

2.3 Soft Computing Method

Both experimental and analytical method for prediction of torque, twist and stiffness at cracking stage was found to be a long process, so there is a need for a solution that provides quick solution and easy one. Soft computing method is employed here which provides some equations for the prediction of parameters.

2.3.1. Multivariate adaptive regression spline (MARS)

This multivariate adaptive regression spline (MARS) provides simple equations to predict the desired parameters. This method was developed by (Friedman,1991). Some researchers name it as black box while others call it white box. In this method, the output is obtained in the form of an equation. This does not provide any basic thing how the final equation is derived. Approximately 70% of experimental results are taken as fitting and others are used for testing. No such basic assumptions are required for this method. The performer is unable to find the relation between various parameters.

T=5.5324+max (0,Fly-350)*0.00154-max(0,350-Fly)*0.0002689 +max (0, spacing) *0.0012240 +max (0, mortar strength-40)*0.0680449 -max (0, 40-mortar strength)*0.0206587

$\theta_{cracking}$ (rad/m)=0.0053610664+max (0, Fly-350)*0.0000008816+max (1.62926-Afl) *0.0002050043 - (40-mortar strength)*0.0000723768

Stiffness at cracking torque = 1053·70258 + max(0, Asl)*0·05110−max(0, 28·2857−Ast)*1·55580−max(0, 1·62926−Afl)*55·36315 + max(0, mortar strength−40)*9·44865 + max(0, 40−mortar strength)*17·13762

2.3.2. WASPAS method

WASPAS stands for weighted aggregated sum product assessment method, was proposed by (Zavadskas et al. in 2012). This method is mainly employed for solution of multi-criteria decision-making problems (MCDM). This is the combination of weighted sum method (WSM) and weighted

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product method (WPM). All the steps of this method are proposed from the works of Madic et al. (2014), Madic et al. (2016) and Zavadskas et al. (2019). Matrix normalization is carried out after matrix initialization in the first step. Third step of the process is prediction of relative importance. Weighted product method is applied in fourth step after which the values are optimized in the final fifth step. The experimental and predicted values by different methods are were reported in Table-2.

Table -2 Torque, twist and stiffness at cracking stage

	P3	P4	P5	C3	C4	C5
Experimental Cracking Toque	5.415	5.415	5.491	5.816	5.816	5.85
Analytical Cracking Toque	5.548	5.548	5.548	5.548	5.548	5.548
Cracking Toque predicted by MARS	5.438347	5.438347	5.438347	5.793526	5.793526	5.793526
Cracking Toque predicted by WASPAS	5.323	5.372	5.414	5.78	5.827	5.875
Experimental Twist at Cracking	0.00545	0.0053	0.00523	0.0055	0.0054	0.0054
Analytical Twist at Cracking	0.0053	0.0053	0.00525	0.004965	0.004924	0.004885
Twist at Cracking by MARS	0.00544457	0.00536107	0.0053610	0.0055239	0.00544041	0.005440
Twist at Cracking by WASPAS	0.005358	0.005315	0.005272	0.00559	0.005547	0.005504
Experimental stiffness at Cracking	993	1021	1027	1067	1077	1084
Analytical stiffness at Cracking	1030	1041	1050	1117	1127	1136
stiffness at Cracking by MARS	987.1459	1009.6961	1009.6961	1054.2798	1076.83	1076.83
stiffness at Cracking by WASPAS	989.7535	999.682	1009.611	1056.201	1066.13	1076.058

3.Interpretation of test results

Cracking torque, twist and stiffness found from various methods were discussed in this section.

3.1. Behaviour of "U" wrap beams

Ten beams were cast and tested. Three beams P3, P4 and P5 are as control specimens for normal strength RC beams having no reinforcement in core. Three beams C3,C4 and C5 covering completely torsionally over reinforced in both directions were cast with M35 and M40 grade concrete and mortar respectively. All the cracks were found having an inclination of 450 to the longitudinal steel. This may be due to induced shear from torsional loading.

3.2. Cracking torque of ferrocement "U" wrap completely over reinforced beams

The torque-twist diagram of ferrocement "U" wrapped beam is linear. This linearity ends once the torque reaches to elastic torque. Torque beyond this point of inflection is almost coincides with the onset of cracking on the specimen. The physical observation when correlated with the torque-twist behavior gives an understanding that the stiffness has reduced after initiation of this micro-cracking.

ISBN: 978-93-90214-19-8

Visible crack is noticed beyond certain stage of the end of the linearity in the torque-twist diagram. That means, in between the stage from change of linearity to formation of visible crack, there could have been formation of few micro-cracks and stiffness might have been reduced. So, the micro-cracking stage is initiated from change of linearity and ends with formation of first macro crack. The macro crack is nothing but formation of a potential crack that could be visible to naked eye. Crack initiation takes place in the longer face first, then on shorter unwrapped face for the plain control specimens P3, P4 and P5 beams. No such difference was observed in the cracking torque of these plain beams. The experimental cracking torque of specimens P3, P4 and P5 were found to be 5.415 kNm, 5.415 kNm and 5.491 kNm respectively .The same for completely over reinforced beams C3, C4 and C5 were found to be 5.816 kNm, 5.186 kNm and 5.85 kNm respectively. The predicted values by soft computing method and by analytical methods were reported in Table.2 and also in Figure 2. If a same beam was cast with M35 grade concrete, the cracking torque would have been 3.66 kNm as predicted by skew bending theory. Due to wrapping, the cracking torque of plain wrapped beams P3, P4 and P5 were found with an increase of 47.95%, 47.95% and 50.03% over an unwrapped beam. Completely over reinforced beams C3, C4 and C5 were found to have an increase in cracking torque 58.91%, 58.91% and 59.84% over the plain unwrapped beam. This proves the effectiveness of wrapping over unwrapping. The completely over reinforced beams C3, C4 and C5 are found to have an increase in their cracking torque 7.41%, 7.41% and 6.54% over their control specimens P3, P4 and P5 respectively. The increase in cracking torque over control specimens may be due to participation of longitudinal reinforcement to resist torque. The same has been presented in Figure 2.

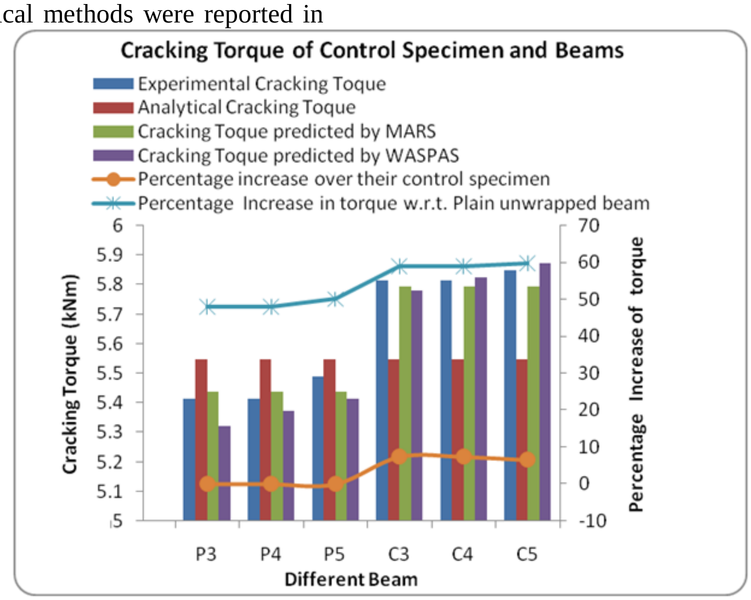

Figure 2: Experimental and predicted torque for various beams with % increase in torque w.r.t. control specimen

The percentage of error in predicted values are presented in Fig.3. Analytical model has predicted the cracking torque as 5.548 kNm for all control specimens and tested beams. This may be due to non consideration of reinforcement in core for cracking torque. Only tensile strength of core concrete and ferrocement are considered for cracking of "U" wrapped beams. The maximum error in analytical model was found to be -5.16 %, for MARS -0.97% and for WASPAS method, it is -1.70% %. Considering the percentage error in prediction of cracking torque, the error is within 5%. So, all the methods for prediction of cracking torque can be suitably employed. Predicted results are found well in agrrement with experimental values.

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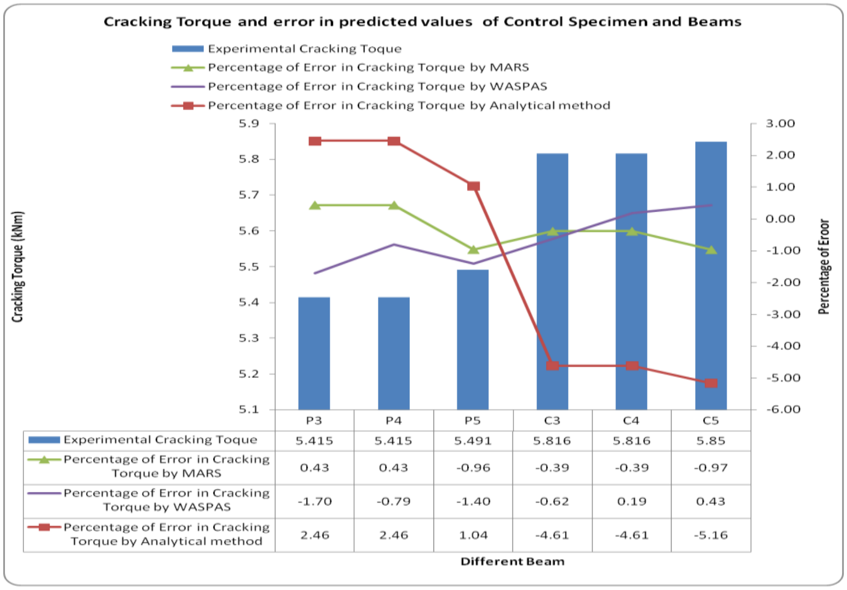

	P3	P4	P5	C3	C4	C5
Experimental Cracking Toque	5.415	5.415	5.491	5.816	5.816	5.85
Percentage of Error in Cracking Torque by MARS	0.43	0.43	-0.96	-0.39	-0.39	-0.97
Percentage of Error in Cracking Torque by WASPAS	-1.70	-0.79	-1.40	-0.62	0.19	0.43
Percentage of Error in Cracking Torque by Analytical method	2.46	2.46	1.04	-4.61	-4.61	-5.16

Figure 3: Experimental cracking torque with percentage of errors in predicted values

3.3. Twist at cracking torque of completely over reinforced beams

Torque and twist are the main parameters to be considered when a section is loaded under torsion. The previous section deals with torque. Twist at cracking torque of beams P3, P4, P5, C3, C4 and C5 was found experimentally 0.00545 rad/m, 0.0053 rad/m, 0.00523 rad/m, 0.0055 rad/m, 0.0054 rad/m and 0.0054 rad/m respectively. The over reinforced beam C5 have undergone 3.25% more twist over its control specimen P5.No such improvement is noticed in beams over their control specimens. The predicted values by analytical method, MARS and WASPAS were presented in Fig.4.

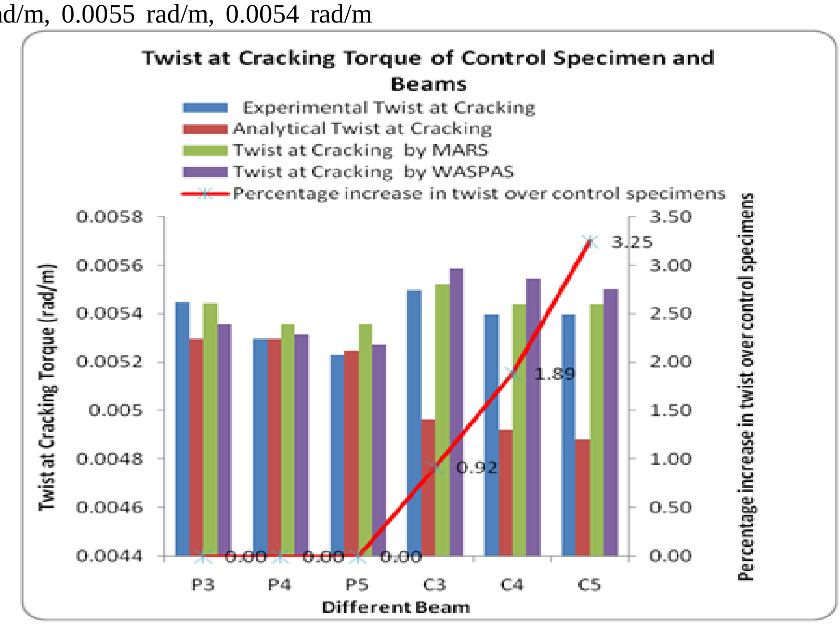

Figure 4: Experimental and predicted twist at cracking torque with percentage of increase in twist over control specimens

The percentage of error in predicted values of twist at cracking by analytical method, MARS and WASPAS are found to be very less. Maximum error in analytical method was -9.73%, for MARS it was 2.51% and in WASPAS method, the same was found to be 2.72%.Except analytical method, other methods can be employed for prediction of cracking twist.Even in analytical method , error was below 10% which was presented in Fig.5.

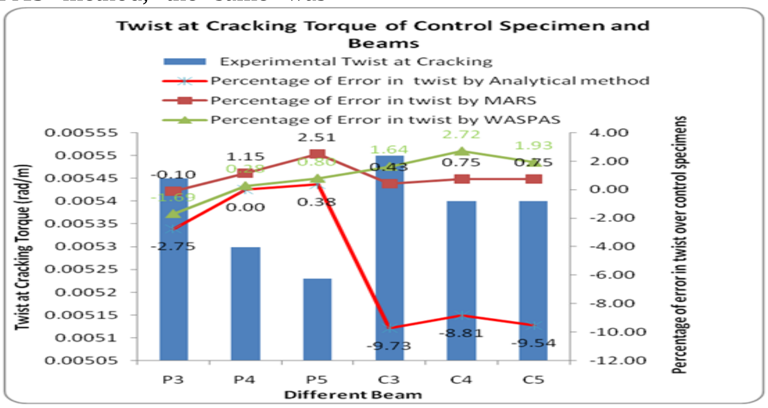

Figure 5: Experimental twist at cracking torque with percentage error in predicted values

3.4. Stiffness at cracking torque of completely over reinforced beams

Stiffness plays a vital role in resisting torque and twist. The stiffness at cracking torque is predicted here for the control specimens and completely over reinforced beams. Stiffness of control specimens and beams P3, P4, P5, C3, C4 and C5 were found to be 993 kNm2, 1021 kNm2, 1027 kNm2, 1067 kNm2, 1077 kNm2 and 1084 kNm2 respectively. The stiffness is found to be increasing with number of mesh layers as found from Table-2. Analytical method overestimates the values while MARS and WASPAS method underestimate the values. All experimental and predicted values are presented in Fig.6. The maximum percentage of error in prediction of stiffness at cracking torque for analytical method, MARS and WASPAS was found to be 4.80%, -1.68% and -2.09% only respectively. This proves accuracy of the models. WASPAS method best predicts the stiffness at cracking torque. Percentage increase I stiffness over control specimen found to be more for 3layers than other layers of beams. Maximum percentage increase was 7.45%. Premature failure may be taking place for beams with more number of layers as the top face was unwrapped.

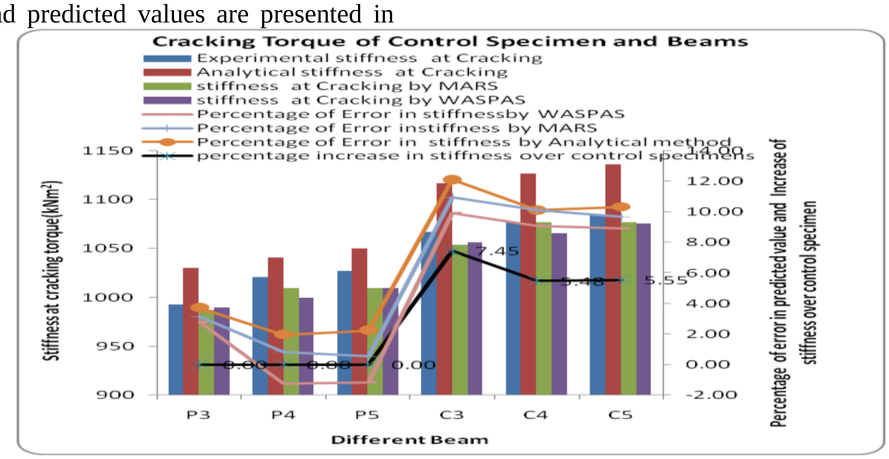

Figure 6: Experimental and predicted stiffness at cracking torque for various beams with percentage of increase in twist w.r.t. control specimen and percentage of error in predicted value

4. Conclusions

In the present investigation, normal strength RC beams were tested with ferrocement “U” wrap. Torque, twist and stiffness capacity at cracking stage were found after the testing of beams. Analytical and soft computing methods were employed to predict the same. The following conclusions were drawn from this research work.

A. For prediction of both torque and twist at cracking stage, analytical model is more suitable when experimental results are not available. MARS is best suited for r cracking torque, while MARS and WASPAS may be employed for twist at cracking torque. However, MARS method is more suitable for prediction of stiffness at cracking stage.

B. Cracking torque is more influenced by the amount of steel provided in core concrete. Maximum 59.84% in cracking torque is found over unwrapped beams. This provides efficacy of “U” wraps.

C. Maximum torque carrying capacity is observed in beams having more reinforcement both longitudinal and transverse direction. Completely over reinforced beams are able sustain 7.40 % more torque than to their control specimen.

D. No such difference is noticed in twist at cracking stage.

E. Maximum 7.4% increase stiffness at cracking torque is observed in three layers of completely over reinforced beams.

Reference

[1] Dong H-L., Wang DY, Wang ZY., and Sun YL. “ Axial compressive behavior of square concrete columns reinforced with innovative closed-type winding GFRP stirrups.” Composite Strcutures, Vol 192, No 15, (2018), 115-125.

[2] Muhammad T., Wang ZY., and Wang DY. “Axial compressive behaviour of square concrete columns reinforced with CFRP sheet strip stirrups.” Submitted to: Construction and Building Materials,(2018)

[3] Karayannis CG., Chalioris CE.,and Sirkelis GM. “Local Retrofit of Exterior RC Beam-Column Joints using Thin RC Jackets - An Experimental Study.” Earthquake Engineering and Structural Dynamics, Vol 37, No 5, (2008), 727-746.

[4] Isleem HF,Wang DY., and Wang ZY. “Axial stress-strain model for square concrete columns internally confined with GFRP hoops.” Magazine Concrete Research, Vol 70, No 20, (2018), 1064–1079.

[5] Yasmeen TO., Ahmed MA.,and Ashteyat. “Performance of RC Beam Strengthened with NSM-CFRP Strip Under Pure Torsion: Experimental and Numerical Study.” International Journal of Civil Engineering,Vol 18, (2020), 585–593.

[6] Chalioris CE. “Torsional Strengthening of Rectangular and Flanged Beams using Carbon Fibre-Reinforced-Polymers - Experimental Study.” Construction and Building Materials, Vol 22, No 1, (2008), 21-29.

[7] Deifalla A.“Torsional Behavior of Rectangular and Flanged Concrete Beams with FRP Reinforcements.” Journal of Structural Engineering,Vol 141, No 12, (2015), 50-68.

[8] Li B, Lam E S S., and Wu B., Wang Y Y. “Experimental Investigation on Reinforced Concrete Interior Beam-Column Joints Rehabilitated by Ferrocement Jackets, Engineering Structures, Vol 56, (2000), 897-909.

[9] ACI Committee 549. Ferrocement-Materials and Applications. ACI Symposium Proceedings SP-61: (1979),Farmington Hills, Michigan.

[10] Shannag MJ, and Mourad S.M. “ Flowable high strength cementitious matrices for ferrocement applications.” Construction and Building Materials, Vol 36,(2012): 933-939.

[11] Chalioris CE, and Thermou GE . “ Pantazopoulou SJ, Behaviour of rehabilitated RC beams with self compacting concrete jacketing – analytical model and test results.” Construction and Building Materials, Vol 55,(2014), 257–273.

[12] Behera G.B, and Bagal D.K.”Torsional Strength Determination of Ferrocement U-Wraps RC Beams with using Different Methods” International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-5, January 2020,pp.4017-4023

[13] Behera GC, Rao TDG, & Rao, CBK , “Torsional Capacity of High Strength Concrete Beams jacketed with ferrocement U wraps.”

Asian Journal of Civil Engineering, Vol 9, No 4 ,(2008), 411-422.

[14] Deifalla A ., and Ghobarah A. "Full Torsional Behavior of RC Beams Wrapped with FRP: Analytical Model." Journal of Composites for Construction, Vol 14, No 3, (2010 a) , 289-300.

[15] Behera GC, Rao TDG, and Rao CBK. " Analytical model for torsional response of RC beams strengthened with ferrocement U-Wraps." SEI, IABSE Structural Engineering International, Vol 24, No 4, (2014), 509-520.

[16] Behera GC, Rao TDG, and Rao CBK. "A study on post cracking torsional behaviour of high strength reinforced concrete beams with ferrocement "U" wraps." DOI: 10.2478/sjce--0012, Slovak Journal of Civil Engineering, Vol 22, No 3, (2014),1 – 12.

[17] Friedman J. Multivariate adaptive regression splines. "The Annals of Statistics." 19, (1991); 1–141.

[18] Zavadskas EK., Turskis Z, Antucheviciene J., and Zakarevicius A. "Optimization of weighted aggregated sum product assessment." Elektron. Elektrotech, Vol 122, (2012), 3–6.

[19] Alireza A.,and Javad K. "New Methods and Applications in Multiple Attribute Decision Making (MADM). (2019), 1-233.

[20] Madi´c M., Gecevska V., Radovanovi´c M., and Petkovi´c D. Multicriteria economic analysis of machining processes using the WASPAS method." J. Prod. Eng., Vol 17(2014),1–6.

[21] Madic M., Antucheviciene J., Radovanovic M., and Petkovic D. "Determination of manufacturing process conditions by using MCDM methods: Application in laser cutting." Eng. Econ.,Vol 27 (2016;), 144–150.

Feasibility Study of Reclaimed Asphalt Pavement (Waste BC) With Virgin Bituminous Mixes

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Abstract - Construction of highway involves huge outlay of investment and major considerations to be kept in mind in case of flexible pavements for design of pavement and its mix design. Increment in the high volume pavements built to bitumen standards in the previous years in India has initiated a demand for strain in the supply of scarce natural resource aggregates. A portion of the present pavements has undergone repairs which included scraping of top layer of asphalt surfacing layer to suit new layers underneath. The removal of the old asphalt layer, solid surfacing layer in the open spaces has prompted natural degeneration. Absence of adequate assets has prompted low volume streets being left in a terrible state. The primary goal of the many of the investigation was to assess the reasonableness of a blend of recovered asphalt concrete, fresh aggregates and a cationic emulsion as a surfacing material for the development of low volume pavements. The use of recycled asphalt in pavements in India assessing the impacts of partial or total substitutions of bituminous concrete by RAP . This paper described variation from 10 to 40% on the mechanical properties of HMA mixtures when reclaimed asphalt pavement (waste bc) and virgin HMA mix are used.

Keywords: RAP, Bituminous concrete, Marshall Stability, Flow value, Density, virgin HMA mix

Introduction

Day to day increasing scope of the road network strongly needs different maintenance methodologies in order to preserve the efficiency of the network to accommodate the volume of traffic safely. This has led to the urge for developing new methods that are affordable and ecologically well disposed, regardless of the consistent increase in costs of bitumen and the intense lack of good aggregates that is vital for a creation of asphalt concrete. Few such methods can be adopted by recycling i.e. by reusing the old asphalt mixes after grinding in different proportions in the new mix. For this one can develop a laboratory program that creates asphalt mixes consisting of proportions of the conventional mixes, which would also reduce the economical aspect of RAP in hot mix asphalt. The boiling of bituminous binder aggregates and creation of enormous amounts of Hot Mix Asphalt (HMA) discharges a lot of greenhouse gases and dangerous pollutants. Also, there is an issue of the shortage of aggregates demanding the transportation of materials from significant distance causing combustion of diesel in transport resulting in emanation of pollutants. On the contrary recycling of black-top asphalts is a Nobel specialized approach which is affordable and favorable for protection of regular assets and ecological issues. Use of Reclaimed Asphalt Pavement (RAP) in asphalt restoration venture has points of interest over fresh aggregates because of the expanding cost of asphalt, scarcity of aggregates and the need to save nature. It is one of the common resources to produce asphalt and is also the most recycled product in the world. Recycling asphalt uses old resources to cut cost for new asphalt pavement and is utilized increasingly more as an innovation. There is a need of specific instructions regulated for RAP use confining the amount that it can be used for each mix. Ongoing studies have indicated that the on an averages of RAP utilized in new blends are around 12% to 15% at national level. The National Asphalt Pavement Association (NAPA) has defined objectives to build the normal RAP content all through the world .Some advantages of Asphalt Recycling are Reuse and

Conservation of non-sustainable power sources, Energy preservation and improved asphalt perfection, Improved asphalt physical properties by alteration of existing grade of aggregates and binding properties of asphalt. Copeland et al. [6] Performance evaluation was conducted on two prepared mixes: a high RAP– hot-mix asphalt (HMA) control mix and a high RAP-WMA for determining dynamic modulus and flow number. Results of flow number and Dynamic modulus tests reflected that high RAP-WMA mix is softer than the high RAP-HMA control mix showing lower flow number and slightly lower E* values. Mallick. R.B. et al. [7] found that high percentage use of RAP offers a very economic method of rehabilitation and its use is very important to save natural resources, money and environmental. Higher RAP substance would require the utilization of aberrant warmth procedures or warm asphalt innovation and include all the more handling and testing of RAP to diminish fluctuation. The utilization of reviving specialists likewise takes into account higher RAP substance to be coordinated into HMA mixes. Louay N. et.al [8] described characterize HMA mixtures containing High Reclaimed Asphalt Pavement content with Crumb Rubber additives. This examination portrayed the lab assessment of traditional HMA mixes and those containing high RAP, crumbed rubber and additives content. It was observed that the added rubber crumbs remolds the asphalt content into less plastic material for the HMA mix with high RAP content as controlled by rheological testing of the asphalt concrete obtained from the mix. Resistance to moisture is also considered, and it was stated that the CR improvised asphalt mix high RAP content performs sufficiently. Alex K. Apeagyei et al [11] studied on the production of high-RAP mixes (i.e., mixes with more than 20% for surface and intermediate, and 25% for base mixes) to assess the qualities of asphalt mix containing distinctive RAP to accomplish a superior comprehension of how high RAP (>20%) influences the mix execution properties that are significant for increasingly tough and savvy black-top. The utilization of higher RAP rates with locally accessible folios was embraced as a way to deal with decrease the interest, on especially more expensive Fresh binder and Fresh aggregates in Virginia. Hugo M.R.D.et.al [10] described reused HMAs can be a decent option for paving of roads, especially if specialized agents are used to lower the temperature at the time of production and to improve their sustainability. Arshad Hussain et.al [9] found the Results of HMA with RAP and without RAP showed satisfactory performance over 16 years of the service period. Study results shows that pavement prepared with RAP content as 35%, can be sustainable if designed properly during its life span. Due to oxidation the penetration and softening point show variation respectively in terms of increase or decrease. Imad L. Al-Qadi et al [11] suggested HMA asphalt gave a saving range from 14 to 34% for a RAP content changing between 20 to 50%. Mixes were planned by Marshall Method at a wide scope of 0 to 100% RAP mixes to deal with low, medium and high traffic loads. The outcomes show that low RAP content up to 30% can be used in wearing courses construction. This paper a mix utilizing these materials was arranged and tests arranged at various RAP substances and tried to decide the ideal RAP content. Same materials mix was utilized supplanting some portion of it by RAP level of 10%, 20%, 30% and 40% and tests arranged of Bituminous Concrete. Marshall Stability, thickness, firmness, flow value, VA, MAV, VFB, s by setting them up at various RAP rate.

RECLAIMED ASPHALT PAVEMENT (RAP)

Removal and reuse of top layer (asphalt) of any existing pavement is named as RAP. In any case full Depth recovery (FDR) is portrayed as removal and reuse of asphalt and base course. RAP can be reused rapidly at goals; in any case it may be aggregated taking everything into account. The necessary degree of RAP is accomplished by pummeling the material in a crusher.RAP has a higher substance of fines on account of defilement of material during mining and excavation. Table.1 shows Characteristics of RAP. RAP can be obtained from Generation from processing of HMA layer, Replacement of pavement at full depth removal and HMA generated wastes at plant. Processing of HMA layer also known as milling is the process removal or scraping of distressed upper layers of any existing pavement to a certain depth. It can be done by using shovels, cranes or scrapers at a certain specified location up to calculated depths and thereafter transporting them for recycling

Table 1: Typical Properties of Reclaimed Asphalt Pavement

S. No.	Parameters	Values
1	Unit Weight (Kg/m³)	1900- 2250
2	Moisture Content	Max 3- 5%
3	Asphalt Content	5- 6%
4	Asphalt Penetration(%) at 25°C	10-80
5	Compacted Unit Weight (Kg/m³)	1500- 1950
6	California Bearing Ratio (CBR)	100% RAP : 20-25%

BITUMINOUS MIX DESIGN

Asphalt/Bituminous solid comprises of a blend of materials ceaselessly reviewed from greatest size , ordinarily under 25 mm, through the fine filler that is less than 0.075 mm. Sufficient bitumen is added to the blend in with the objective that the compacted blend is feasibly impervious and will have commendable dissociative and flexible properties. The bituminous mix arrangement intends to choose the degree of bitumen, filler, fine and coarse aggregates to create a blend which is serviceable, solid, sturdy and affordable. The target of the blend configuration is to deliver a bituminous blend by proportioning different segments in order to have-

1. Adequate bitumen to guarantee a strong pavement
2. Adequate strength to resist shear under traffic at higher temperature
3. Conferring enough air voids in the compacted bitumen to think about additional compaction by traffic
4. Workability to allow ease of laying pavement without segregating it
5. Reducing cracking caused due to repetitive traffic loading
6. Preventing cracks caused due to shrinkage at low temperatures

THEORETICAL CONSIDERATIONS FOR RAP

For arrangement of Bituminous Concrete (BC) materials according to Marshall Test Data for Virgin Bituminous Concrete (As Per ASSHTO T245) is given as maximum for 5.8% bitumen by weight of total mix. Whereas Ministry of Road transport & Highway (MORTH) specified the values for stability (kg) 900 minutes, flow (mm) 2 to 4, Va (%) 3 to 5, VMA (%) 13 minutes and Marshal Quotient as 2 to 5 and are also shown in Table-2.

Table -2 Summary for Marshall Test Data for Virgin Bituminous concrete

Physical & Volumetric Characteristics of Virgin Bituminous concrete (VG-30) As Per ASSHTO T245						As Per MORTH
Bitumen (%)	5.4	5.6	5.8	6.0	6.2	-
Density (gm/cc)	2.388	2.421	2.443	2.432	2.424	-
Stability (Kg)	902.12	1071.74	1232.70	1008.38	905.33	900
Flow, mm	2.33	2.63	3.27	4.33	5.30	2 to 4
VA (%)	6.75	5.17	3.99	3.85	4.14	3 to 5
VMA(%)	15.77	14.79	14.19	14.52	15.23	13
VFB(%)	57.22	65.08	71.89	73.49	72.80	65 to 75

AGGREGATES &MINERALS

For arrangement of Bituminous blends (BC) materials according to Ministry of Road Transport &Highway(MORTH) are evaluating and shown in Table 3 and a specific kind of binder in required amounts were required according to Marshall Procedure and Properties of mineral aggregates for Elongation Index and FI is Flakiness Index obtained by Experiment are shown in Table 4

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Table 3. Adopted aggregate Gradation for BC (MORTH)

Sieve size (mm)	Percentage Passing of Material	Required Limit (MORTH) Table No: 500-17
19	100	100
13.2	99.66	79-100
9.5	84.24	70-88
4.75	63.41	53-71
2.36	52.95	42-58
1.18	38.37	34-48
600µ	30.08	26-38
300µ	20.71	18-28
150µ	14.72	12-20
75 µ	05.68	04-10

Table 4: Properties of Mineral aggregates

Property	Test method	Result Obtained By Experiment	Requirements as per MORTH , Table No: 500-16
Aggregate Impact Value, %	IS 2386 (Part IV)	21.6	30 max
Water Absorption Value, %	IS 2386 (Part III)	0.7	2 max
Specific Gravity	IS 2386 (Part II)	2.66	2.5-3.0
Combined (EI + FI) Index, %	IS 2386 (Part I)	25.2	35 max
Stripping, %	IS 6241	98	Min retained coating 95
Water Sensitivity	AASTHO 283	92	Retained Tensile Strength 80%

BINDER

The Viscosity Grade (VG 30) infiltration grade bitumen is utilized as binder for readiness of Mix, Specific Gravity G =1.01. Its significant property is given in Table -5.

Table-5 Properties of bitumen (VG-30)

Properties	Test Method	Value	Requirements as per IS 73: 2006
Penetration, (25°C, 100 g, 5s), 0.1 mm	IS 1203-1978	64	50-70
Softening point (Ring and Ball), °C	IS 1205-1978	48	≥47
Ductility at 27°C (5cm/min)	IS 1208-1978	78	-
Specific gravity	IS 1202-1978	1.01	-
Viscosity at 60°C, Poise	IS 1206-1978	2570	≥2400
Viscosity at 135°C	IS 1206-1978	725	≥350

METHODOLOGY AND TESTING PROCEDURE

The experimental analysis is divided into two parts, First part illustrates the tests performed on the materials (Aggregates, Bitumen, and RAP), and second part deals with the tests carried out on bituminous mixes. Showing various tests led on the bituminous mix in with varying binders and their amount, and RAP concentrates in the mix. The aggregates were taken from a neighboring mixing plant. A mix utilizing these aggregates was arranged and tests at various binder contents and finding its

ISBN: 978-93-90214-19-8

optimum amount. Similar aggregates mix was utilized and some portion of it was supplanted by RAP level of 10%, 20%, 30% and 40% was determined at Bitumen 5.8% were used for preparing Concrete of Bitumen content. Characteristics like Marshall Stability, Flow value and thickness were seen at rates of bitumen 5.8% three samples by preparing at each RAP rate are shown in Table-6 and Fig.1,2,3,4,5,6

Table-6 Marshall Test Data for BC with RAP 10%, 20%, 30% & 40%

Reclaimed Asphalt Pavement (RAP) (%)	Density (gm/cc)	Stability (Kg)	Flow (mm)	MQ	Voids in Aggregates (VA) (%)	Voids Filling Bitumen (VFB)(%)	Mineral Aggregate Voids (MAV) (%)
RAP (10%)	2.359	882.12	2.23	3.96	7.01	56.84	16.24
RAP (20%)	2.402	1043.35	2.9	3.6	5.31	63.92	14.71
RAP (30%)	2.434	1148.85	3.2	3.59	4.05	70.17	13.57
RAP (40%)	2.416	979.03	4.43	2.21	4.75	66.56	14.2

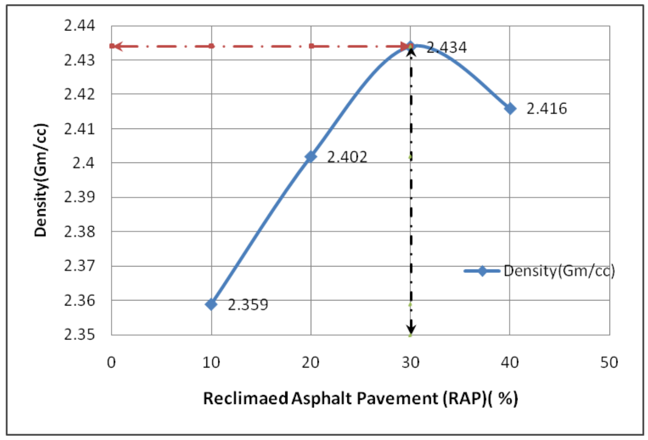

Fig-1 Reclaimed Asphalt Pavement (RAP) (%) with Density (Gm/cc)

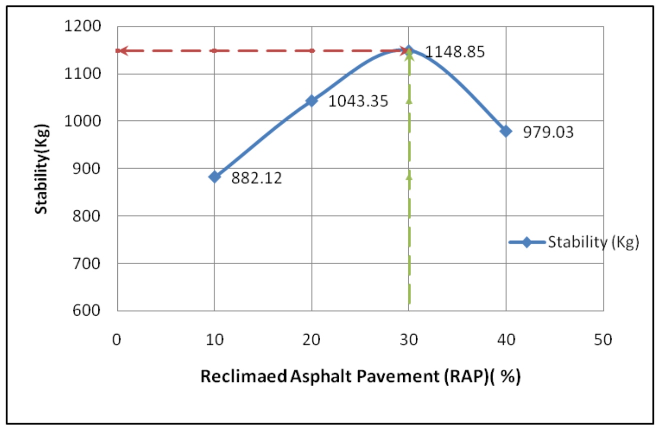

Fig-2 Reclaimed Asphalt Pavement (RAP) (%)with Stability (Kg)

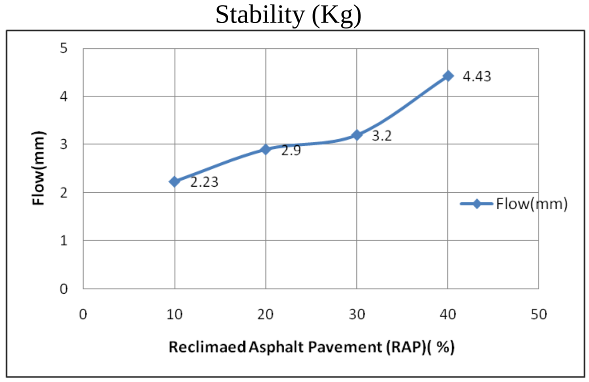

Fig-3 Reclaimed Asphalt Pavement (RAP) (%) with Flow (mm)

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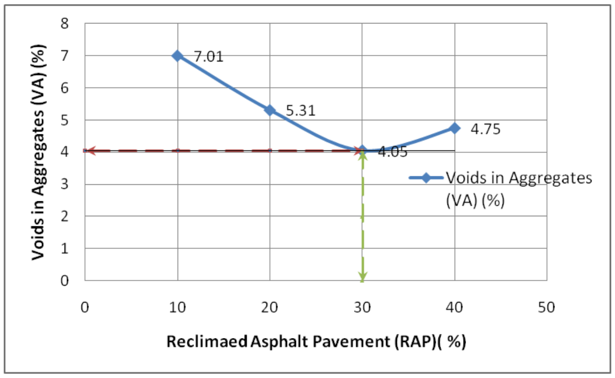

Fig-4 Reclaimed Asphalt Pavement (RAP) (%)with Voids in Aggregates (VA) (%)

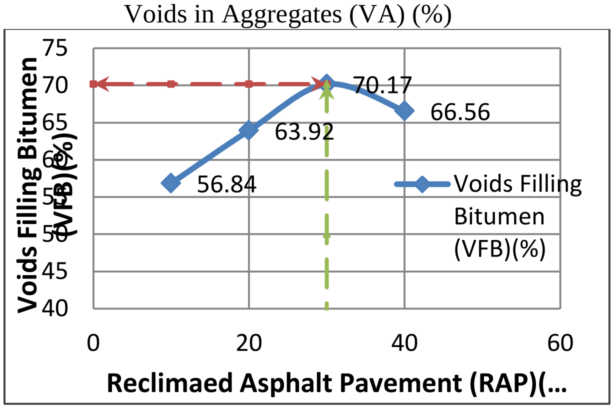

Fig-5 Reclaimed Asphalt Pavement (RAP) (%)with Voids Filling Bitumen (VFB)(%)

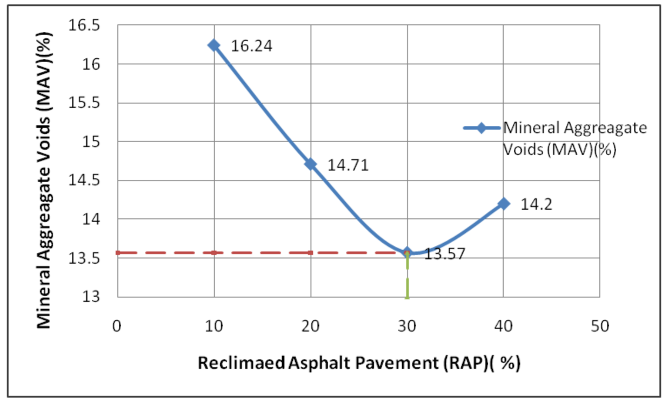

Fig-6 Reclaimed Asphalt Pavement (RAP) (%) with Mineral Aggregate Voids (MAV) (%)

VALIDATION OF DATA

The comparison between the MORTH Specification (section 500) mix design requirements of bituminous mix Obtained Value of mix @ 5.8 % by Virgin Aggregate carried out with Obtained Value of mix of RAP @ 30% of Experimental value of Density(gm/cc), Stability(Kg), Flow(mm), Voids in Aggregates (VA) (%),Voids Filling Bitumen (VFB)(%) and Mineral Aggregate Voids (MAV)(%). The comparison of MORTH as well as value obtained from this study shows a close agreement as Shown in Table-7

Table-7 Comparison between the MORTH Specification (section 500) mix design and Obtained Value of mix of RAP @ 30%

Parameters	Specified Limit as per MORTH	Obtained Value of mix @ 5.8 % by Virgin Aggregate.	Obtained Value of mix of RAP @ 30%	% Difference
Density(Gm/cc)	-	2.443	2.434	0.37
Stability(Kg)	900	900	1148.85	-27.65
Flow(mm)	2 to 4	3	3.20	-6.67
Voids in Aggregates (VA) (%)	3 to 5	4	4.05	-1.25
Voids Filling Bitumen (VFB)(%)	65 to 75	70	70.17	-0.24
Mineral Aggregate Voids (MAV)(%)	13	13	13.57	-4.38

RESULTS AND DISCUSSIONS

Based on result and observation of tests performed on the various different parameter for the analysis, computation of Optimum Binder Content (OBC) of BC, Marshall Properties of bituminous concrete with or without adding RAP, following conclusion can be made.

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1) Marshall Stability at RAP 30% is 1148.85 kg against the requirement is 900 Kg the maximum Marshall stability found at RAP 27.65%.
2) The density of bituminous mix is 2.443gm/cc and density at RAP 30% is 2.434 the variation of maximum density is negligible
3) Flow value at OBC of virgin mix is 3.27 mm and flow value at RAP content 30% is 3.20mm the difference is negligible and acceptable
4) Voids in aggregate VA at OBC of virgin mix is 4.0% value at RAP content 30% is 4.05% the difference is negligible and acceptable.
5) Voids in Mineral aggregate MAV at OBC of virgin mix is Found 13.57 % the difference is negligible and The requirement is 13 % Minimum.
6) Voids filled with bitumen, VFB at OBC of virgin mix is 71.79% value at RAP content 30% is 70.17 % the difference is well within the limits(65-75%)

Nomenclature and Symbols used in present study

ABC -Aggregate Base Course
AC - Asphalt Content
AASHTO - American Association of State Highway & Transportation Officials
BC - Bituminous Concrete
FHWA - Federal Highway Administration
HMA - Hot Mix Asphalt
HMAC - Hot Mix Asphalt Concrete
MORTH - Ministry of Road Transport & Highway
NHDP -National Highway development program
NCHRP - National Corporation highway research program
OBC -Optimum Binder Content
RAP - Reclaimed Asphalt Pavement
VA - Voids in Aggregates
VG - Viscosity Graded
VFB - Voids filling Bitumen
MAV - Mineral Aggregates Voids

REFERENCES

[1] Specifications for road and bridge works", MORTH (fifth revision), published by Indian Roads Congress
[2] ASTM D 6927, "Test Method for Marshall Stability and Flow of Bituminous Mixtures", American Society for testing and materials
[3] Indian Standard, "Paving Bitumen Specification (4th Revision)", IS 73:2013, Bureau of Indian Standard, New Delhi
[4] Indian Standard, "Method for Test for aggregates for Concrete", IS 2386 (Part I & Part II), Bureau of Indian Standard, New Delhi
[5] Indian Standard, "Method for Testing Tar & Bituminous Materials", IS 1203-1978, Bureau of Indian Standard, New Delhi
[6] Copeland et al. (2007) "Field evaluation of high reclaimed asphalt pavement- warm mix asphalt project". Journal of the Transportation Research Board, No. 2179, Florida, USA, PP 93-101.
[7] Mallick. R.B. et al. (2008). "Using-Warm Asphalt Technology to Incorporate High Percentage of Reclaimed Asphalt Pavement Material in Asphalt Mixture" Transportation Research Record 2051, Washington, D.C, PP 71-79.
[8] Louay N. Mohammad & Samuel B. Cooper (2011), "Characterization of HMA mixtures containing High Reclaimed Asphalt Pavement content with Crumb Rubber additives", ASCE Journal NOV
[9] Arshad Hussain and QiuYanjun (2012). "Evaluation of Asphalt Mixes Containing Reclaimed Asphalt Pavement for Wearing Courses" IPCSIT vol. 26, PP 43-48.
[10] Hugo M.R.D. Silva , Joel R.M. Oliveira, Carlos M.G. Jesus (2012). "Are totally recycled hot mix asphalts a sustainable alternative for road Paving?" Resources, Conservation and Recycling 60, PP 3848, Elsevier
[11]. Alex K. Apeagyei, Trenton M. Clark and Todd M. Rorrer (2013),"Stiffness of High-RAP Asphalt Mixtures: Virginia's Experience", ASCE, Journal of Materials in Civil Engineering
[12] Imad L. Al-Qadi et al (2014) "Reclaimed Asphalt Pavement –A Literature Review". Illinois Center for Transportation Series No. 07-001, PP 1-19.

Study on properties of Self Compacting Concrete with the use of metakaolin

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Abstract - Self-Compacting Concrete (SCC) has the ability to flow and self-compact under it's own weight.It's main benefit that can reduce the construction time and labour cost. Self-Compacting concrete (SCC) has the ability to spread smoothly in congested reinforced elements due to its flowability and use of small size aggregates. SCC use in residential or large infrastructure for densely reinforced elements such as walls, precast members etc. Various agricultural and industrial waste are use as supplementary cementitious material in Self compacting concrete which enhances the properties of prepared self-compacting concrete. Metakaolin is also used as supplementary cementitious material. Metakaolin is a pozzolanic material and enhances the fresh as well as hardened properties of self-compacting concrete if it uses as partial replacement of cement.

Keywords: Metakaolin, Concrete mix, Compressive strength, Split Tensile strength, Flexural strength.

Introduction

Day to day increasing scope of the road network strongly needs different maintenance methodologies in order to preserve the efficiency of the network to accommodate the volume of traffic safely. This has led to the urge for developing new methods that are affordable and ecologically well disposed, regardless of the consistent increase in costs of bitumen and the intense lack of good aggregates that is vital for a creation of asphalt concrete. Few such methods can be adopted by recycling i.e. by reusing the old asphalt mixes after grinding in different proportions in the new mix. For this one can develop a laboratory program that creates asphalt mixes consisting of proportions of the conventional mixes, which would also reduce the economical aspect of RAP in hot mix asphalt. The boiling of bituminous binder aggregates and creation of enormous amounts of Hot Mix Asphalt (HMA) discharges a lot of greenhouse gases and dangerous pollutants. 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VA (%)	6.75	5.17	3.99	3.85	4.14	3 to 5
VMA(%)	15.77	14.79	14.19	14.52	15.23	13
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For arrangement of Bituminous blends (BC) materials according to Ministry of Road Transport &Highway(MORTH) are evaluating and shown in Table 3 and a specific kind of binder in required amounts were required according to Marshall Procedure and Properties of mineral aggregates for Elongation Index and FI is Flakiness Index obtained by Experiment are shown in Table 4

Table 3. Adopted aggregate Gradation for BC (MORTH)

Sieve size (mm)	**Percentage Passing of Material**	**Required Limit (MORTH) Table No: 500-17**
19	100	100
13.2	99.66	79-100
9.5	84.24	70-88

4.75	63.41	53-71
2.36	52.95	42-58
1.18	38.37	34-48
600µ	30.08	26-38
300µ	20.71	18-28
150µ	14.72	12-20
75 µ	05.68	04-10

Table 4: Properties of Mineral aggregates

Property	**Test method**	**Result Obtained By Experiment**	**Requirements as per MORTH , Table No: 500-16**
Aggregate Impact Value, %	IS 2386 (Part IV)	21.6	30 max
Water Absorption Value, %	IS 2386 (Part III)	0.7	2 max
Specific Gravity	IS 2386 (Part II)	2.66	2.5-3.0
Combined (EI + FI) Index, %	IS 2386 (Part I)	25.2	35 max
Stripping, %	IS 6241	98	Min retained coating 95
Water Sensitivity	AASTHO 283	92	Retained Tensile Strength 80%

BINDER

The Viscosity Grade (VG 30) infiltration grade bitumen is utilized as binder for readiness of Mix, Specific Gravity G =1.01. Its significant property is given in Table -5.

Table-5 Properties of bitumen (VG-30)

Properties	**Test Method**	**Value**	**Requirements as per IS 73: 2006**
Penetration, (25°C, 100 g, 5s), 0.1 mm	IS 1203-1978	64	50-70
Softening point (Ring and Ball), °C	IS 1205-1978	48	≥47
Ductility at 27°C (5cm/min)	IS 1208-1978	78	-
Specific gravity	IS 1202-1978	1.01	-
Viscosity at 60°C, Poise	IS 1206-1978	2570	≥2400
Viscosity at 135°C	IS 1206-1978	725	≥350

METHODOLOGY AND TESTING PROCEDURE

The experimental analysis is divided into two parts, First part illustrates the tests performed on the materials (Aggregates, Bitumen, and RAP), and second part deals with the tests carried out on bituminous mixes. Showing various tests led on the bituminous mix in with varying binders and their amount, and RAP concentrates in the mix. The aggregates were taken from a neighboring mixing plant. A mix utilizing these aggregates was arranged and tests at various binder contents and finding its optimum amount. Similar aggregates mix was utilized and some portion of it was supplanted by RAP level of 10%, 20%, 30% and 40% was determined at Bitumen 5.8% were used for preparing Concrete of Bitumen content. Characteristics like Marshall Stability, Flow value and thickness were seen at rates of bitumen 5.8% three samples by preparing at each RAP rate are shown in Table-6 and Fig.1,2,3,4,5,6

Table-6 Marshall Test Data for BC with RAP 10%, 20%, 30% & 40%

ISBN: 978-93-90214-19-8

Reclaimed Asphalt Pavement (RAP) (%)	Density (gm/cc)	Stability (Kg)	Flow (mm)	MQ	Voids in Aggregates (VA) (%)	Voids Filling Bitumen (VFB)(%)	Mineral Aggregate Voids (MAV) (%)
RAP (10%)	2.359	882.12	2.23	3.96	7.01	56.84	16.24
RAP (20%)	2.402	1043.35	2.9	3.6	5.31	63.92	14.71
RAP (30%)	2.434	1148.85	3.2	3.59	4.05	70.17	13.57
RAP (40%)	2.416	979.03	4.43	2.21	4.75	66.56	14.2

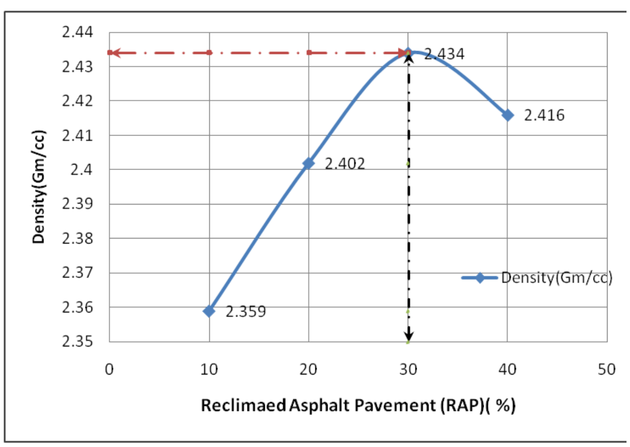

Fig-1 Reclaimed Asphalt Pavement (RAP) (%) with Density (Gm/cc)

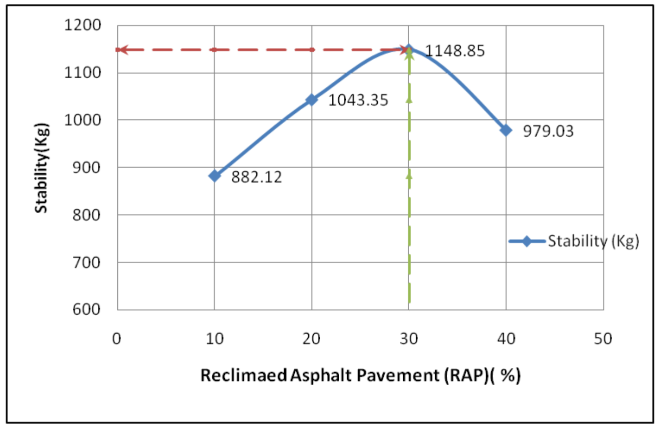

Fig-2 Reclaimed Asphalt Pavement (RAP) (%)with Stability (Kg)

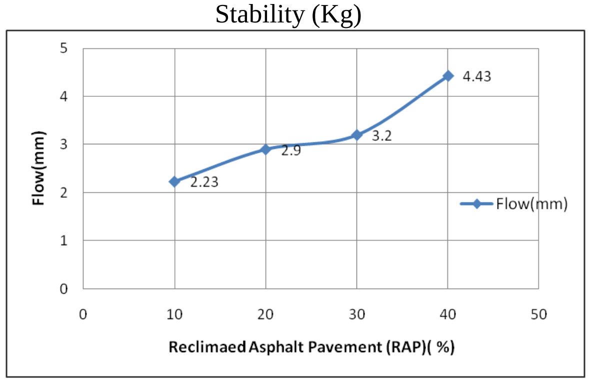

Fig-3 Reclaimed Asphalt Pavement (RAP) (%) with Flow (mm)

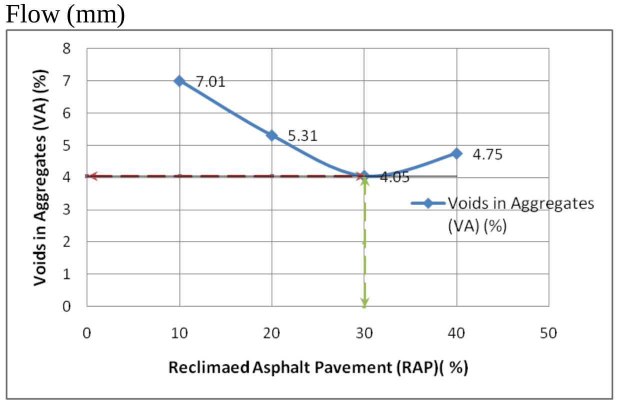

Fig-4 Reclaimed Asphalt Pavement (RAP) (%)with Voids in Aggregates (VA) (%)

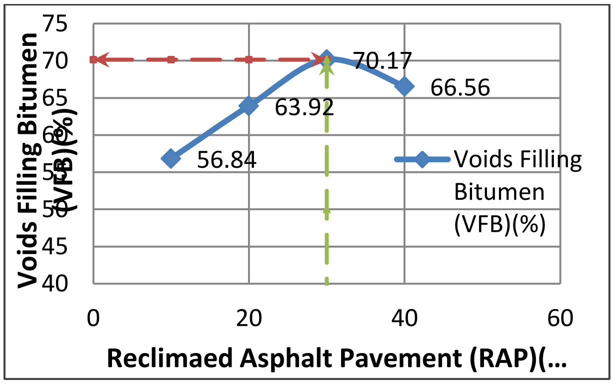

Fig-5 Reclaimed Asphalt Pavement (RAP) (%)with Voids Filling Bitumen (VFB)(%)

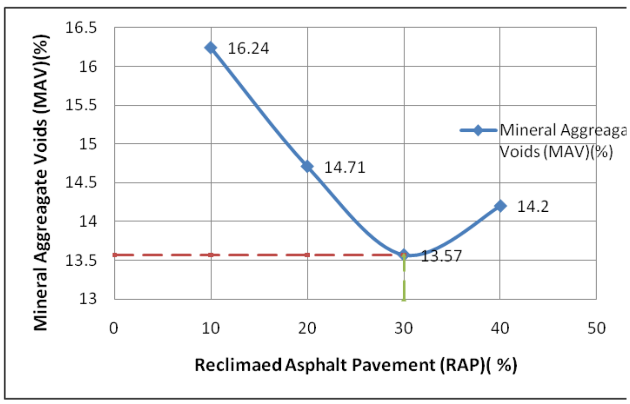

Fig-6 Reclaimed Asphalt Pavement (RAP) (%) with Mineral Aggregate Voids (MAV) (%)

VALIDATION OF DATA

The comparison between the MORTH Specification (section 500) mix design requirements of bituminous mix Obtained Value of mix @ 5.8 % by Virgin Aggregate carried out with Obtained Value of mix of RAP @ 30% of Experimental value of Density(gm/cc), Stability(Kg), Flow(mm), Voids in Aggregates (VA) (%),Voids Filling Bitumen (VFB)(%) and Mineral Aggregate Voids (MAV)(%). The comparison of MORTH as well as value obtained from this study shows a close agreement as Shown in Table-7

Table-7 Comparison between the MORTH Specification (section 500) mix design and Obtained Value of mix of RAP @ 30%

Parameters	Specified Limit as per MORTH	Obtained Value of mix @ 5.8 % by Virgin Aggregate.	Obtained Value of mix of RAP @ 30%	% Difference
Density(Gm/cc)	-	2.443	2.434	0.37
Stability(Kg)	900	900	1148.85	-27.65
Flow(mm)	2 to 4	3	3.20	-6.67
Voids in Aggregates (VA) (%)	3 to 5	4	4.05	-1.25
Voids Filling Bitumen (VFB)(%)	65 to 75	70	70.17	-0.24
Mineral Aggregate Voids (MAV)(%)	13	13	13.57	-4.38

RESULTS AND DISCUSSIONS

Based on result and observation of tests performed on the various different parameter for the analysis, computation of Optimum Binder Content (OBC) of BC, Marshall Properties of bituminous concrete with or without adding RAP, following conclusion can be made.

1) Marshall Stability at RAP 30% is 1148.85 kg against the requirement is 900 Kg the maximum Marshall stability found at RAP 27.65%.
2) The density of bituminous mix is 2.443gm/cc and density at RAP 30% is 2.434 the variation of maximum density is negligible
3) Flow value at OBC of virgin mix is 3.27 mm and flow value at RAP content 30% is 3.20mm the difference is negligible and acceptable
4) Voids in aggregate VA at OBC of virgin mix is 4.0% value at RAP content 30% is 4.05% the difference is negligible and acceptable.
5) Voids in Mineral aggregate MAV at OBC of virgin mix is Found 13.57 % the difference is negligible and The requirement is 13 % Minimum.
6) Voids filled with bitumen, VFB at OBC of virgin mix is 71.79% value at RAP content 30% is 70.17 % the difference is well within the limits(65-75%)

Nomenclature and Symbols used in present study

ABC -Aggregate Base Course
AC - Asphalt Content
AASHTO - American Association of State Highway & Transportation Officials
BC - Bituminous Concrete
FHWA - Federal Highway Administration
HMA - Hot Mix Asphalt
HMAC - Hot Mix Asphalt Concrete
MORTH - Ministry of Road Transport & Highway
NHDP -National Highway development program
NCHRP - National Corporation highway research program
OBC -Optimum Binder Content
RAP - Reclaimed Asphalt Pavement
VA - Voids in Aggregates
VG - Viscosity Graded
VFB - Voids filling Bitumen
MAV - Mineral Aggregates Voids

REFERENCES

[1] Specifications for road and bridge works", MORTH (fifth revision), published by Indian Roads Congress

[2] ASTM D 6927, "Test Method for Marshall Stability and Flow of Bituminous Mixtures", American Society for testing and materials

[3] Indian Standard, "Paving Bitumen Specification (4th Revision)", IS 73:2013, Bureau of Indian Standard, New Delhi

[4] Indian Standard, "Method for Test for aggregates for Concrete", IS 2386 (Part I & Part II), Bureau of Indian Standard, New Delhi

[5] Indian Standard, "Method for Testing Tar & Bituminous Materials", IS 1203-1978, Bureau of Indian Standard, New Delhi

[6] Copeland et al. (2007) "Field evaluation of high reclaimed asphalt pavement- warm mix asphalt project". Journal of the Transportation Research Board, No. 2179, Florida, USA, PP 93-101.

[7] Mallick. R.B. et al. (2008). "Using-Warm Asphalt Technology to Incorporate High Percentage of Reclaimed Asphalt Pavement Material in Asphalt Mixture" Transportation Research Record 2051, Washington, D.C, PP 71-79.

[8] Louay N. Mohammad & Samuel B. Cooper (2011), "Characterization of HMA mixtures containing High Reclaimed Asphalt Pavement content with Crumb Rubber additives", ASCE Journal NOV

[9] Arshad Hussain and QiuYanjun (2012). "Evaluation of Asphalt Mixes Containing Reclaimed Asphalt Pavement for Wearing Courses" IPCSIT vol. 26, PP 43-48.

[10] Hugo M.R.D. Silva , Joel R.M. Oliveira, Carlos M.G. Jesus (2012). "Are totally recycled hot mix asphalts a sustainable alternative for road Paving?" Resources, Conservation and Recycling 60, PP 3848, Elsevier

[11]. Alex K. Apeagyei, Trenton M. Clark and Todd M. Rorrer (2013),"Stiffness of High-RAP Asphalt Mixtures: Virginia's Experience", ASCE, Journal of Materials in Civil Engineering

[12] Imad L. Al-Qadi et al (2014) "Reclaimed Asphalt Pavement –A Literature Review". Illinois Center for Transportation Series No. 07-001, PP 1-19.

Effects of Jet angle, Position and Flow pattern on Jet Flocculation Process

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Abstract:
Jet- mixing is widely utilized in varied process units for various functions. Flocculation process is a crucial unit of water treatment plant and usually fitted with mechanical stirrer or vanes. The matter connected with maintenance and running of mechanical elements are crucial. It is therefore requisite to explore different easier devices free from such restraint. Use of Jet mixing in Flocculation process is a good resolution, as it do not have any moving components within the reactor. This research work is an effort underway to design a jet flocculator which can work effectively in flocculation process and able to remove turbidity beneficially. The main objective of the analysis work is to point out the utilization of jet mixing as a substantial alternative in flocculation process. Present investigation is to check the impact of varied parameters like nozzle diameter, angle of inclination, flow pattern and jet position on velocity gradient in circular flocculation chamber.

Keywords: Flocculation, Jet mixing, turbidity, velocity Gradient.

I. INTRODUCTION

Coagulation and Flocculation processes are very inherent in all water treatment schemes. [5] gives cursory information about the important units (Coagulation, Flocculation, Clarification) of water treatment plant and explains about the basic things required to understand what customer wish to monitor in the units of WTP. The ample variety of flocculation mixing tools have been used in water treatment. They include varied shaft arrangement as vertical shaft mechanical mixers, horizontal shaft mechanical mixers, and hydraulic mixing systems. In mechanical flocculators, paddles, paddle reels or rakes are used for stirring of the water. The various problems and disadvantages associated with the maintenance and running of mechanical components of conventional mixers, necessitate to explore and find other simpler devices free from various constraints and can be suitably used in flocculation process. Amongst all Jet mixing in flocculation has become optimal alternative to conventional impeller mixing. Jet mixing in flocculation process plays crucial role in determining the final quality of water, affects the subsequent processes of flocculation and ultimately cost of water treatment plant hence it has become a key area of research. Lack of effective supervision and most importantly managerial control are the major problem encountered by operating units of most of the WTP. [10] & [8] in his experimentation studied the efficiency of free jets and recommended the usage of Jet flocculator by removing turbidity of raw water which was observed as good as that of conventional flocculators fitted with mechanical stirrers with negligible maintenance cost. [4] worked on the design of (below & above 5 MLD) and [12] on 3 MLD capacity units and found efficient. [6] stated that jet mixing in tanks are more efficient as compared to the conventional impeller mixers. Hence it can be concluded that jet flocculator seems to be a viable alternative and system may be advantageously used for sustained satisfactory service.

Researchers undertook diverse modifications in the jet techniques and compare the performance with conventional flocculation process. [7] studied the principle of tapered flocculation and concluded that a tapered jet flocculator is as efficient as a mechanical flocculator. [1] conducted an experimental study on a gravel-packed channel flocculator. [13] studied the performance of a jet mixed separator (JMS) which has a series of porous plates inserted in the channel perpendicular to a flow which passes water creating a jets effect by mixing the water gently. The turbidity obtained from JMS effluent was constantly below I NTU at the hydraulic retention time of about 1 hour. In view of this [9] provides a comprehensive review of flocculation mechanism from empirical and theoretical perspective, which discuss its practical applications with its future need. Traditionally, flocculators have been distinguished considering the velocity gradient. Velocity Gradient is dominant parameter and used by researchers to characterize mixing. Smoluchowski equation was extended by [2] for a plane laminar flow to a general laminar or turbulent fluid motion. They defined the root-mean-square velocity gradient ‘G’ which can be calculated as $G=(P/\mu V)^{1/2}$ Where, P=Power, V= volume, µ = Absolute viscosity. [3] has stated the Camp-Stein equation for the root-mean- square velocity gradient G, leading to the conclusion that G is only a valid parameter for flocculation. Various aspects of Jet flocculators were studied by researchers. [10] introduced three new indices to explain the dependence of the performance of different flocculators on the kinetic and geometric properties. The limitation of this indices are, they are unable to explicate the variations in the performance of the jet flocculator as per as shape, jet diameter, L/d ratio etc is concerned. Jet flocculator takes advantage of all the factors which includes easy installation, low maintainance cost, no requirement of any structural reinforcement of the tank & cheaper in cost as compared to conventional mixing devices. Even though guidelines for the design of jet flocculator are not available.

Present investigation is an attempt to study the experimental performance for various combinations and conditions of jet in a circular flocculation chamber. Particularly, to analyze the effect of different position, angle & diameter of jet at various flow pattern on the velocity gradient.

II. EXPERIMENTAL SETUP & PROCEDURE

The tests were conducted on Circular flocculation chamber placed at the height of 1.4m from the ground level having diameter 0.82m. The foremost setup consist of a circular overhead tank of 500 lit capacity. In a overhead tank Required turbidity of 100 NTU is attained by addition of 96 gm of artificial clay, kaolin clay. Preparation of the turbid water & to prolong required turbidity was quite crucial since the artificially generated turbidity settles down quickly in the tank. Stirrer arrangement is installed in the tank which revolves persistently throughout the experiment which avoids the settlement of clay at bottom of the tank and to sustain the required turbidity. Comparing the chemical coagulants for various aspects [11] Concluded that for floc removal, Aluminum Sulphate (Alum) coagulant is more efficient than that of Ferric Chloride. Alum Coagulant dose of 23 gm is added in the tank. The ultimate performance of flocculator depends upon both coagulation and flocculation processes. Therefore it is meaningful to give importance to flash mixing of water sample after addition of coagulant prior going to flocculation chamber. Flash mixing gives dissipation of chemicals in the water which assist the slow mixing process for better floc growth. Arrangement is significant in maintaining the requisite turbidity. The turbidity of water sample is checked by drawing water time to time. Turbidity is constantly supervised so that at any instant it should not surpass or lower down the required limit. Flocculation is a hydrodynamic process of slow mixing. It results in the formation of large and readily settleable flocs by bringing the finely divided matters into contact, resorted to agglomerate the flocs to grow which can be achieved by flowing water through a jet of various diameters in the chamber under the gravity from the overhead tank. Head of 0.79m is maintained throuout the procedure by proper arrangements in flocculation chamber and overhead tank.

Flocculation process lasts for about 30-60 mins. For all experimental readings retention time of 30 mins is considered for flocculation process in chamber. Jet mixers are simple and reliable having no moving parts and hardly subject to any wear. Once the Steady state is achieved in flocculation chamber the outlet point is fixed upto the depth of water filled in the tank. The outlet is adjusted and fixed by screw at that position and the readings are noted. Experimentation is carried out considering 90^0 & 45^0 angle of jet in the flocculation tank at various points in the chamber for radial and straight flow pattern. The setup is flexible for changing diameter of jet and number of jets throughout the experimentation. The jets of desired angles are fabricated. It can be easily fixed, removed and also can change the position as required in flocculation chamber. Pressure gauge is attached to every point of jet which is examined and maintained for all the readings. Water was discharged through a jet of various diameter into the tank under gravity. Proper plumbing and water drainage arrangement promotes no water accumulation in any part of the setup. The discharge nozzle was located at the various positions of the tank. Jet is applied for one set of reading keeping others point of nozzle closed which produced three dimensional flow in the tank which mixes all of the contents homogenously. For each of the location readings are taken and compared.

Experiments were conducted on a circular flocculation chamber for twelve different jet diameters 2, 2.5, 3, 3.57, 3.97, 4.75, 5.5, 6, 7, 8, 9 and 10mm. Nephelo turbidity meter is used to check the turbidity. Turbidity was measured for each sample for the retention time of 30 mins and 1 hr. Optimum dose of coagulant is obtained using Jar test apparatus. The temperature of raw water was in the range of 24^0C to 28^0C in the experiments. For 45^0 and 90^0 jet inclinations considering radial and straight flow pattern an average of three samples tested is reported. Total seven positions are considered for 90^0 jet inclinations. Out of which four positions are inspected at the side of a tank which are 1A, 2A, 3A & 4A shown in Fig.1. where 1A position starts from inlet of water in flocculation chamber. Rest of the three submerged positions are identified at the bottom of the tank termed as bottom up, bottom ½ & bottom ¾ position as shown in Fig 2,3 & 4 respectively. Whereas for 45^0 jet four positions are inspected as 1A, 2A, 3A & 4A for circular tanks.

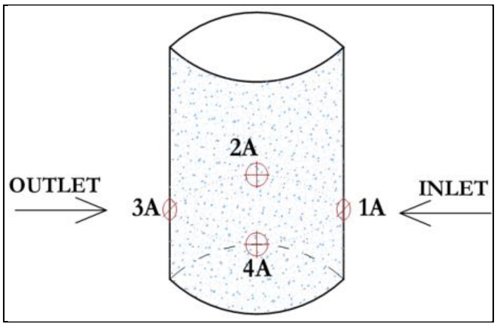

Fig. 1-Wall positions in Circular tank

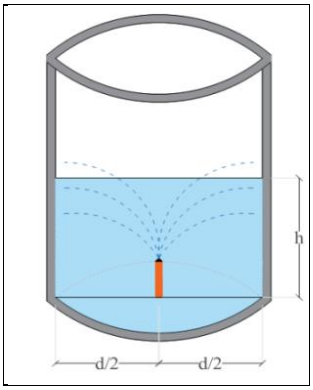

Fig. 2-Bottom Up position in Circular tank

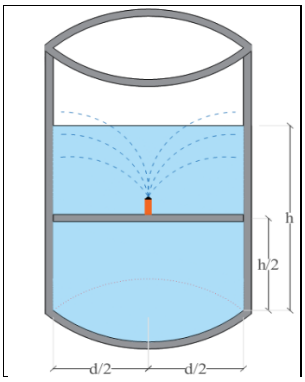

Fig. 3-Bottom 1/2 position in Circular tank

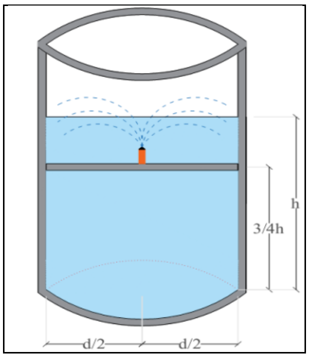

Fig. 4-Bottom 3/4 position in Circular tank

III. RESULT AND DISCUSSION

In view of the objectives for the study, the velocity gradient (G) data collected with respect to various modifications in Jet angle, Position and Flow pattern was analyzed. The comparative assessment of G values as a function of various conditions of parameters is processed using various descriptive as well as inferential statistics tests. The descriptive statistics like mean, standard deviation, standard error, etc. and inferential statistical tests like single group T test, Analysis of Variance (ANOVA) etc. were employed to analyze the data. In present investigation Circular tank with 0.82m diameter is constructed for experimentation where head of water was kept constant. Effect of Straight and radial flow pattern on 90^0 & 45^0 jet angle considering various positions of jet in flocculation process was analyzed for four different condition and combinations as follows.

Condition A- Jet angle 90^0, Straight flow pattern, Head of water 0.79m & Jet positions of 1A, 2A, 3A, 4A, Bottom Up, ½ and 3/4.

ISBN: 978-93-90214-19-8

Experimentation was conducted on all the seven position for all the twelve jet diameters. Table I represents the significant velocity gradient value for each of the jet diameter amongst all seven positions when jet angle is 90^0 and flow pattern is straight.

Table I : Comparative Assessment of the Velocity Gradient G values to determine the better jet diameter for Circular Tank (H= 0.79 m, Straight Flow and Jet angle of 90°)

Jet Diameter(m)	Position	Mean	±SD	Min	Max	F	P
0.002	1A	68.5	±2.0	66.1	71.7	9.5	<0.01
0.0025	Bottom Up	67.8	±1.7	66.1	69.5		
0.003	Bottom Up	63.2	±1.9	61.3	65.1		
0.00357	Bottom Up	65.8	±2.2	63.6	68.0		
0.00397	Bottom Up	63.8	±2.9	60.9	66.7		
0.00475	Bottom Up	63.2	±2.8	60.4	66.0		
0.0055	Bottom Up	64.7	±1.9	62.8	66.6		
0.006	1/2	60.8	±1.3	59.5	62.1		
0.007	3/4	59.3	±1.3	58.0	60.6		
0.008	3/4	58.3	±2.2	56.1	60.5		
0.009	3/4	60.9	±2.2	58.7	63.1		
0.01	3/4	56.0	±1.9	54.1	57.9		

SD: Standard Deviation; **Min**: Minimum; **Max**: Maximum; **F**: 'F' ratio; **P**: Probability

Table I presents results of the comparative assessment of the velocity gradient 'G' values obtained for the flocculation process carried out in a circular chamber, angle of jet being 90^0, straight flow pattern, with jet positions of 1A, 2A, 3A, 4A, Bottom Up, ½ and ¾ for all twelve jet diameters. The study results show that the G value varied between 56 s^{-1} (diameter of jet 0.01m and position 3/4) and 68.5 s^{-1} (diameter of jet 0.002m and position 1A). The comparative assessment using one way ANOVA showed that there is statistically significant ($p<0.01$) difference in the G values obtained vis-à-vis various design parameters. However, amongst all the conditions, significantly ($p<0.01$) better results for (G value) were obtained for the following condition i.e. Circular tank, Angle of Jet 90^0, Straight Flow pattern, 0.01 m diameter of jet and 3/4 jet position (**Fig. 5**).

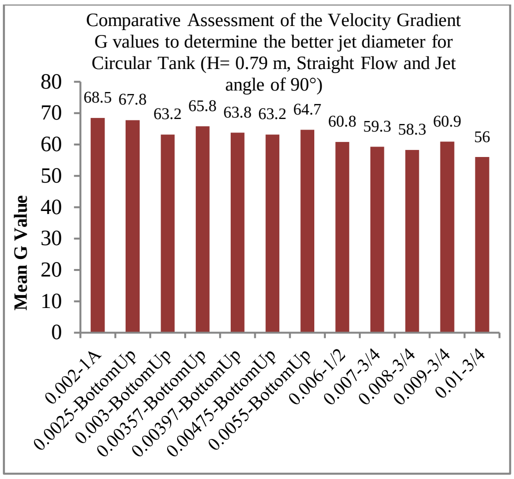

Fig. 5- Comparative Assessment of the Velocity Gradient G values to determine the better jet diameter for Circular Tank (H= 0.79 m, Straight Flow and Jet angle of 90°)

Condition B- Jet angle 90^0, Radial flow pattern, Head of water 0.79m & Jet positions of 1A, 2A, 3A & 4A.

Table II represents the significant velocity gradient value for each of the jet diameter amongst all four positions of jet when jet angle is 90^0 and flow pattern is radial.

Table II- Comparative Assessment of the Velocity Gradient G values to determine the better jet diameter for Circular Tank (H= 0.79 m, Radial Flow and Jet angle of 90°)

Jet Diameter(m)	Position	Mean	SD	Min	Max	F	P
0.002	2A	69.5	±2.9	66.6	72.4	9.587	<0.01
0.0025	1A	72.5	±1.9	70.6	74.4		
0.003	1A	60.5	±1.3	59.2	61.8		
0.00357	1A	71.0	±2.8	68.2	73.8		
0.00397	1A	67.9	±1.3	66.6	69.2		
0.00475	1A	69.8	±2.2	67.6	72.0		
0.0055	1A	70.3	±2.9	67.4	73.2		
0.006	1A	70.7	±2.2	68.5	72.9		
0.007	1A	72.9	±1.3	71.6	74.2		
0.008	1A	73.8	±2.9	70.9	76.7		
0.009	1A	75.9	±2.2	73.7	78.1		
0.01	1A	76.4	±2.9	73.5	79.3		

SD: Standard Deviation; **Min**: Minimum; **Max**: Maximum; **F**: 'F' ratio; **P**: Probability

Table II presents results of the comparative assessment of the Velocity Gradient (G) values recorded for design parameters for Circular tank, Angle of jet 90^0, Radial Flow and different jet positions as well as jet diameters. The study results show that the G value varied between 60.5 s^{-1} (diameter of jet 0.003m and position 1A) and 76.4 s^{-1} (diameter of jet 0.01m and position 1A). The comparative assessment using one way ANOVA showed that there is statistically significant ($p<0.01$) difference in the G values obtained vis-à-vis various design parameters. However, amongst all the conditions, significantly ($p<0.01$) better results for (G value) were obtained for the following condition i.e. Circular tank, Angle of Jet 90^0, Radial Flow pattern, 0.003 m diameter of jet and 1A jet position (**Fig. 6**) and for all remaining jet diameters from 0.0025 m to 0.01m the 1A position of jet yielded better G values.

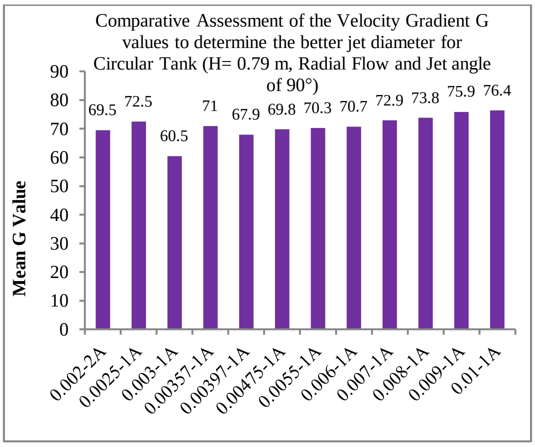

Fig. 6- Comparative Assessment of the Velocity Gradient G values to determine the better jet diameter for Circular Tank (H= 0.79 m, Radial Flow and Jet angle of 90°)

Condition C- Jet angle 45^0, Straight flow pattern, head of water 0.79m & jet positions of 1A, 2A, 3A & 4A.

Table III represents the significant velocity gradient value for all twelve jet diameters comparing all four positions of jet, when jet angle is 45^0 and flow pattern is straight.

Table III- Comparative Assessment of the Velocity Gradient G values to determine the better jet diameter for Circular Tank (H= 0.79 m, Straight Flow and Jet angle of 45°)

Jet Diameter(m)	Position	Mean	SD	Min	Max	F	P
0.002	4A	73.0	±2.8	70.2	75.8	3.3	<0.05
0.0025	1A	73.4	±2.9	70.5	76.3		
0.003	1A	71.7	±2.8	68.9	74.5		
0.00357	1A	70.4	±2.8	67.6	73.2		
0.00397	1A	68.7	±1.9	66.8	70.6		
0.00475	1A	69.6	±1.3	68.3	70.9		
0.0055	3A	74.3	±1.7	72.8	76.2		
0.006	1A	74.2	±2.9	71.3	77.1		
0.007	1A	75.2	±2.2	73.0	77.4		
0.008	1A	75.2	±1.7	73.5	76.9		
0.009	3A	73.5	±2.2	71.3	75.7		
0.01	1A	76.4	±1.3	75.1	77.7		

SD: Standard Deviation; **Min**: Minimum; **Max**: Maximum; **F**: 'F' ratio; **P**: Probability

Table III presents results of the comparative assessment of the Velocity Gradient (G) values recorded for design parameters for Circular tank, Angle of jet 45^0, Straight flow and mentioned four jet positions as well as for twelve jet diameters. The study results show that the G value varied between 68.7 s^{-1} (diameter of jet 3.97mm and position 1A) and 76.4 s^{-1} (diameter of jet 10mm and position 1A). The comparative assessment using one way ANOVA showed that there is statistically significant ($p<0.05$) difference in the G values obtained vis-à-vis various design parameters. However, amongst all the conditions, significantly ($p<0.05$) better results for (G value) were obtained for the following condition i.e. Circular tank, Angle of Jet 45^0, Straight Flow pattern, 3.97mm diameter of jet and 1A jet position (**Fig.7**). In maximum of the jet diameters the 1A jet position yielded better G values.

ISBN: 978-93-90214-19-8

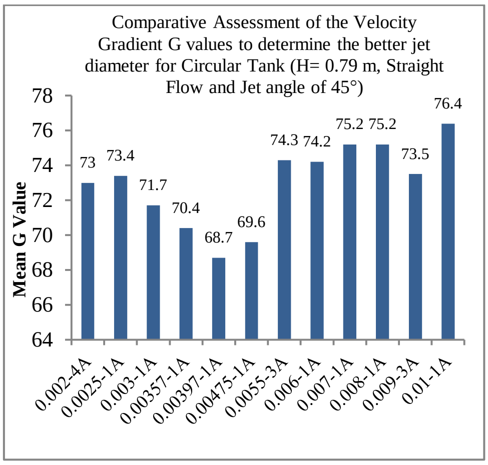

Fig. 7- Comparative Assessment of the Velocity Gradient G values to determine the better jet diameter for Circular Tank (H= 0.79 m, Straight Flow and Jet angle of 45°)

Condition D- Jet angle 45^0, Radial flow pattern, head of water 0.79m & jet positions of 1A, 2A, 3A & 4A.

Table IV represents the significant velocity gradient value for all twelve jet diameters comparing all four positions of jet, when jet angle is 45^0 and flow pattern is radial.

Table IV- Comparative Assessment of the Velocity Gradient G values to determine the better jet diameter for Circular Tank (H=0.79 m, Radial Flow and Jet angle of 45°)

Jet Diameter (m)	Position	Mean	SD	Min	Max	F	P
0.002	1A	72.8	±2.8	70.0	75.6	2.8	<0.05
0.0025	1A	72.1	±2.9	69.2	75.0		
0.003	1A	71.5	±1.7	69.8	73.2		
0.00357	1A	70.4	±2.2	68.2	72.6		
0.00397	3A	68.4	±1.9	66.5	70.3		
0.00475	1A	70.7	±2.2	68.5	72.9		
0.0055	1A	75.3	±2.8	72.5	78.1		
0.006	1A	72.5	±2.2	71.4	75.8		
0.007	1A	75.7	±2.2	73.5	77.9		
0.008	1A	74.3	±1.9	72.4	76.2		
0.009	1A	72.8	±2.2	70.6	75.0		
0.01	1A	75.2	±2.8	72.4	78.0		

SD: Standard Deviation; **Min**: Minimum; **Max**: Maximum; **F**: 'F' ratio; **P**: Probability

Table IV presents results of the comparative assessment of the Velocity Gradient (G) values recorded for design parameters for Circular tank, Angle of jet 45^0, Radial Flow and different jet positions as well as jet diameters. The study results show that the G value varied between 68.4 s^{-1} (diameter of jet 0.00397m and position 3A) and 75.7 s^{-1} (diameter of jet 0.007m and position 1A). The comparative assessment using one way ANOVA showed that there is statistically significant ($p<0.05$) difference in the G values obtained vis-à-vis various design parameters. However, amongst all the conditions, significantly ($p<0.05$) better results for (G value) were obtained for the following condition i.e. Circular tank, Angle of Jet 45^0, Radial Flow pattern, 0.00397 m diameter of jet and 3A jet position (**Fig.8**). However, beyond this jet diameter remaining all jet diameters yielded better G values at position 1A as compare to remaining three jet positions (2A, 3A, 4A).

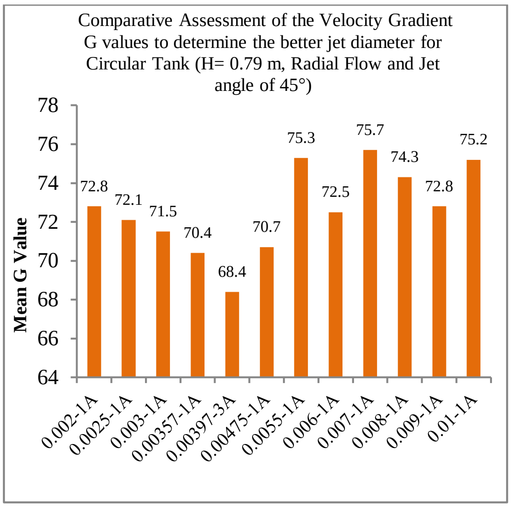

Fig. 8- Comparative Assessment of the Velocity Gradient G values to determine the better jet diameter for Circular Tank (H= 0.79 m, Radial Flow and Jet angle of 45°)

Comparative Analysis

Comparative Analysis for G values of all the four above mentioned conditions and combinations are carried out. Out of which the best design condition for each of the combination is listed in the **Table V.** The variation in residual turbidity as a function of retention time is examined for retention time of 30 mins & 1 hr. Percentage turbidity removal for 90 & 45 degree jet is observed for straight flow as well as for radial flow condition. Experimental study shows that larger diameters of jets performs marginally better than smaller diameters of jet.

Results does not shows remarkable variations in the values of turbidity removal for both 45^0 & 90^0, still 90^0 jet performs marginally better than that of 45^0 jet. It is observed that circular flocculation chamber shows turbidity removal is in the range of 80% to 90% considering all jet diameters which is notable.

Table V- Determination of best design condition for Circular Chamber with Head of Water – 0.79 m

Angle	Flow pattern	Diameter (m)	Position	Mean	SD	Min	Max	F	P
90	Straight	0.01	3/4	56.0	±1.9	54.1	57.9	39.9666	<0.01
90	Radial	0.003	1A	60.5	±1.3	59.2	61.8		
45	Straight	0.00397	1A	68.7	±1.9	66.8	70.6		
45	Radial	0.00397	3A	68.4	±1.9	66.5	70.3		

SD: Standard Deviation; **Min**: Minimum; **Max**: Maximum; **F**: 'F' ratio; **P**: Probability

Subsequent to above, the data of Velocity Gradient (G) values obtained for different conditions was analyzed to determine the best design condition for Circular tank with Head of water 0.79 m. **Table V** presents results of this comparative assessment. The G values showed variation between 56±1.9 (design parameter conditions angle of jet 90^0, Straight Flow and 0.001 m diameter of jet) and 68.7±1.9 (design parameter conditions angle of jet 45^0, Straight Flow and 0.00397 m diameter of jet). Based on the data it is evident that for the Circular tank, the angle of jet should be 90^0 at straight Flow pattern considering 3/4 jet position and 0.01 m jet diameter for optimum flocculation (**Fig.9**).

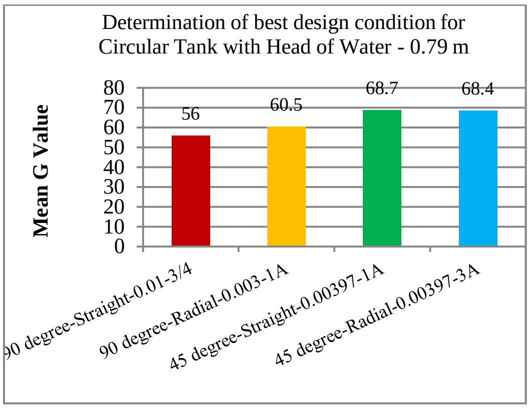

Fig. 9- Determination of best design condition for Circular Tank with Head of Water – 0.79 m

IV CONCLUSION

The outcomes of the current experiment of jet flocculation in circular flocculation chamber is summarized as follows:

1. Circular chamber shows maximum turbidity removal efficiency in the range of 80 to 90% which is significant at a 30 minutes of detention time for preferable flocculation. Turbidity removal efficiency can be increased by increasing the Retention time by one hour after completion of flocculation process.

2. For Condition A, when Angle of Jet is 90^0 and Flow Pattern is Straight
   In view of the data it is evident that significantly ($p<0.01$) better G value was obtained with jet diameter of 0.01 m and ¾ jet position.

3. For Condition B, when Angle of Jet is 90^0 and Flow Pattern is Radial
   It is noticed that for such a combination of position and diameter of jet, better G value ($p<0.01$) was obtained with jet diameter of 0.003 m and 1A jet position.

4. For Condition C, when Angle of Jet is 45^0, Flow Pattern is Straight
   From the data it is evident that significantly ($p<0.01$) better G value was obtained with jet diameter of 0.00397 m and 1A jet position.

5. For Condition D, when Angle of Jet is 45^0, Flow Pattern is Radial
   Remarkable ($p<0.01$) Velocity Gradient value was obtained with jet diameter of 0.00397 m and 3A jet position.

6. Amongst all the four combinations, the jet angle of 45^0 at Radial Flow pattern considering 3/4 jet position and for 10mm jet diameter gives optimum flocculation.

7. Jet angle of 90^0 with straight flow encourage proper mixing in circular flocculation chamber for nearly all twelve jet diameters.

8. 1A positions(on the tank side) works effectively when compared with 2A, 3A & 4A nearly for all combinations with all jet diameters.

ISBN: 978-93-90214-19-8

References

[1] Bhole A.G., and Viraraghavan T., (1990). Gravel Packed Baffled Channel Flocculator', J. Environ. Eng. 116, pp.795-796.

[2] Camp T.R., and Stein, P.C. (1943). Velocity Gradients and internal work in fluid motion. Journal of the Boston Society of Civil Engineers, Section, American Society of Civil Engineers, Vol. 30, pp. 219-237.

[3] Cleasby J.L., (1984). Is Velocity Gradient A Valid Turbulent Flocculation Parameter?, J. Environmental. Engineering, ASCE, Vol. 110(5), No. EE5, pp.875-897.

[4] Dhabadgaonkar, S.M. (2008). Jet Floccus-Clarifiers: Appropriate Technology for Water Treatment in India, Journal of Indian Water Works Association, pp.21-39.

[5] Engelhardt, T.L. (2010). Coagulation, Flocculation and Clarification of Drinking Water. Drinking water sector, Hach Company, pp.1-57.

[6] Fosset H. and Prosser L.E. (1951). Proc. I. Mech. E., 160,224, idem: Trans. Instn. ChemEngrs., 29, 322.

[7] Kumar, N. and Pani, B.S. (2003). 'Tapered flocculation with hydraulic jets', Journal of Indian Water Works Association, Bombay, 35(3), pp.167 - 172.

[8] Kumar, N.S., Pani, B.S. and Joshi, S.G. (2012). Residual Turbidity In Hydraulic Jet Flocculators, ISH Journal of Hydraulic Engineering,15(2), pp.108-117.

[9] Oyegbile, B., Ay, P. and Satyanarayana, N. (2016). Flocculation kinetics and hydrodynamic interactions in natural and

[11] Randive P.S, Singh D.P, Bhole A.G, Varghese V, Badar A.M., (2020), Evaluation of Fractal Growth Characteristic of Flocs for Aluminium Sulphate & Ferric Chloride using Microscopy Method, Advances in Civil Engineering and Infrastructural Development, pp- 487-494, https://link.springer.com/book/10.1007/978-981-15-6463-5

[12] Subramanian, T. and Nair, S. (2012). Experimental and Numerical Analysis On Horizontal Jet Flocculates For Small Water Supply Schemes, International Journal of

[10] Pani, B.S. and Patil, L.G. (2007). Single-basin engineered flow systems: A review, Environ. Eng. Res., pp. 1-47.jet flocculators, Journal of Hydro-environment Research, 1(1), pp. 20-29.

Modern Engineering Research (IJMER), 2(4), pp.1534-1539.

[13] Watanabe Y., Kasahara S. and Iwasaki Y. (1998). Enhanced flocculation/sedimentation process by a jet mixed separator, Water Science and Technology, 37(10), pp.55-67.

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Study on the Effectiveness of Admixtures in Repairing and Enhancing the Properties of Concrete

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Abstract— In all kinds of construction, cracks are found. We all dream of a home that is structurally stable and appealing, but it's not so easy. Overcoming natural calamities man made disasters, construction faults, inappropriate design, cracks are formed on the building. Though the cracks in buildings cannot be avoided totally they can be prohibited by using enough material and technique of repair. On timely recognition of such cracks and adopting preventive measure are essential. Active cracks require special attention as they gradually propogate.So, it is necessary to recognize the type of crack, crack pattern and their cause along with the defensive measures to be taken to deal with the cracks. Crack X plast a chemical admixture with non shrinking property, RoffSupercrete a liquid white Acrylic Polymer admixture, Ground Granulated Blast Furnace Slag (GGBS)byproduct from steel industry and fly ash a byproduct of thermal power plant are used in this study. An attempt has been made to study the effectiveness of the above chemical and mineral admixtures.

Index Terms— *chemical admixture, cracks, mineral admixture, repair.*

I. INTRODUCTION

When prepared properly, concrete is the most durable and long-term product to use. Good quality concrete cannot be achieved in ease. The following are the reasons for cracking of concrete. Concrete does not require much water to achieve its strength, but in usage at sites more water usage is done for improved workability. This excess water affects the concrete strength to a greater extent. Shrinkage is another reason for cracking. After concrete hardening, it shrinks. This is due to the evaporation of surplus water in concrete. Concrete will dry rapidly which also causes cracking. Foundation poured in cold season also contributes to cracking. This clearly indicates crack may appear at any time so it is important to repair the cracks.

Materials

A. *Materials used in the study is shown in the below table.*

Table I-Materials used

Material	Classification
Cement	**Ordinary Portland Cement**
Fine Aggregate	M-Sand
Coarse Aggregate	12.5 mm gravel
Water	Potable
Ground Granulated Blast Furnace Slag (GGBS)	Portland
Fly ash (FA)	Class F
Crack X Paste	Polymer modified type
Roff Shotcrete Acrylic Polymer	Acrylic polymer

II. METHODOLOGY

The methodology carried out in this work is presented in figure 1.

Collection of materials

↓

Initial Test on Materials

↓

Mix design

↓

Casting of cylinders

↓

Testing of cylinders

↓

Repairing of cylinders using GGBS, FA,CXP & RSAP

↓

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Testing of repaired cylinder

Results and discussions

Conclusion

Figure 1 Methodology

III. EXPERIMENTAL INVESTIGATION

After the collection of materials, initial test on cement, M Sand and gravel was conducted. Fineness test, consistency, setting time and specific gravity test was conducted for cement. Sieve analysis test was conducted for both aggregates and fineness modulus was calculated. Along with it tests like specific gravity, bulk modulus was also done. Mix proportioning was carried out using IS 10262-2009. M25 grade concrete in the mix ratio 1:1.62:2.57:0.4 is used. 12 cylinders of size 150 mm diameters, 300 mm height was cast along with 6 cubes of 150 mm size and cured. After curing of cylinders and cubes, they are tested for compressive strength and split tensile strength at 7, 14 and 28 days. The tested cylinders are repaired for their cracks. Initially the depth of crack was measured using crack measuring device. Later initial propagation of crack for the first day was observed which was compared with its 7th day propagation length. After this using GGBS in the powder form was made to paste by adding water and then injected into cracks of three cylinders and for the three cylinders, Fly ash mixed with water was used for sealing of cracks as in figure 2. Using Crack X paste, three cylinders and Roff Shotcrete Acrylic Polymer the remaining three cylinders were repaired. Later left for drying for 24 hours and tested for split tensile test using Compression Testing Machine.

Figure 2 Casting and repairing of cylinders

IV. RESULTS AND DISCUSSIONS

The results of compressive strength of concrete cube indicates that mix proportioning done is correct. The target strength is achieved and is shown in Figure 3.

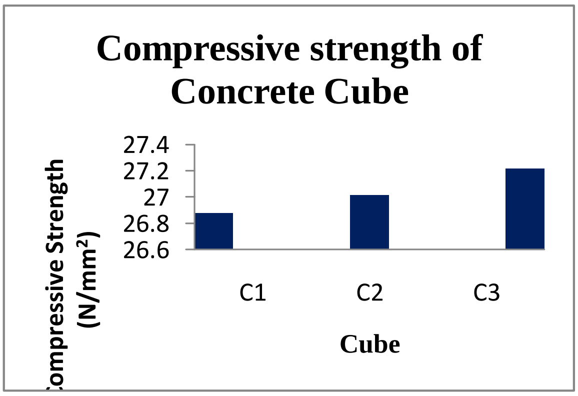

Figure 3 Compressive strength of concrete cube

The Split tensile Strength of concrete cylinders before and after repairing using GGBS and FA indicates that strength is enhanced using mineral admixtures. The comparison of strengths is shown in figure 4 and 5 Using chemical admixtures is shown in figure 6 and 7.

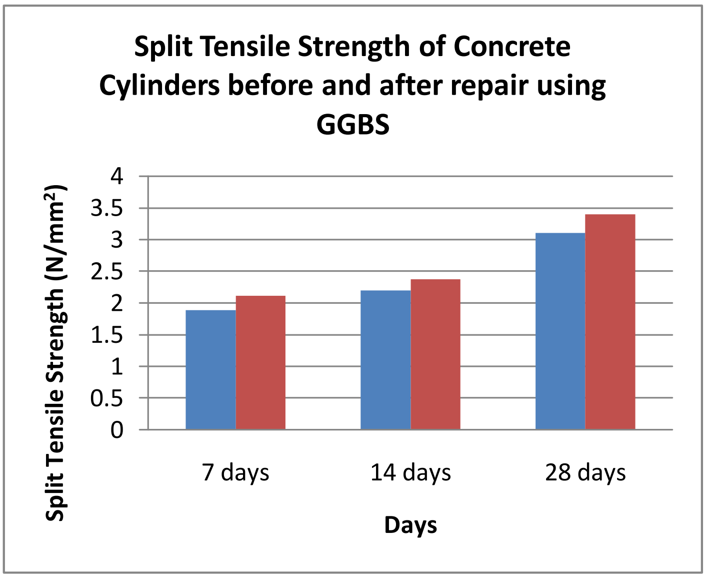

Figure 4. Split Tensile Strength of Concrete Cylinders before and after repair using GGBS

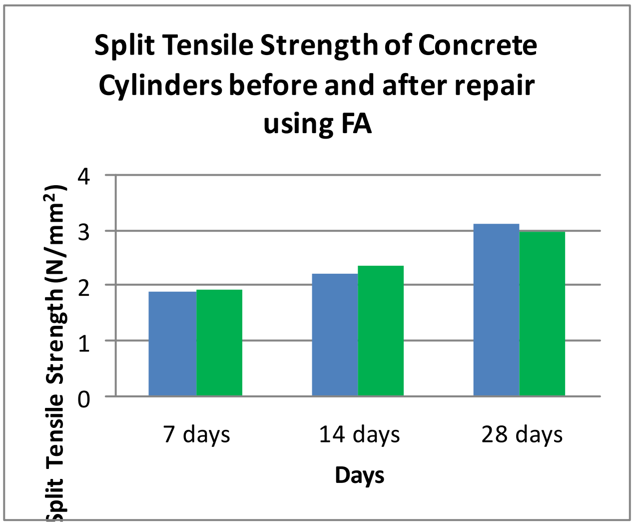

Figure 5. Split Tensile Strength of Concrete Cylinders before and after repair using FA

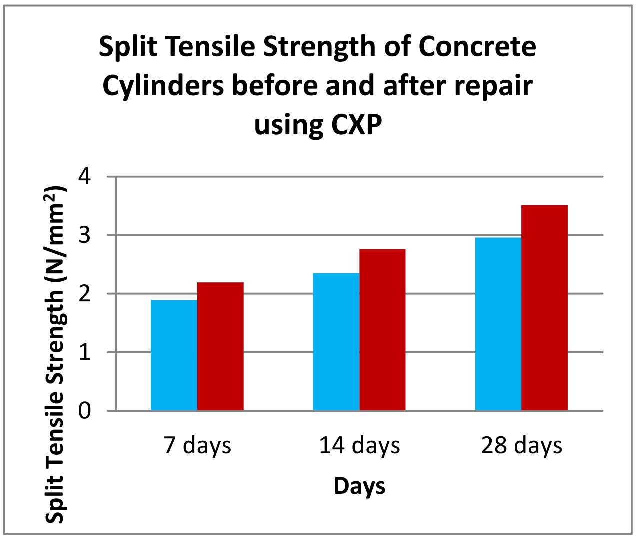

Figure 6. Split Tensile Strength of Concrete Cylinders before and after repair using CXP

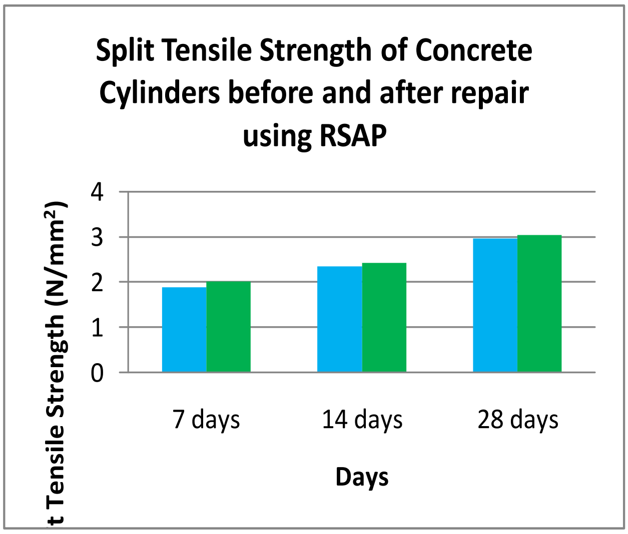

Figure 7. Split Tensile Strength of Concrete Cylinders before and after repair using RSAP

V. COMPARATIVE STUDY

The efficiency of mineral and chemical admixtures are presented as comparative study. The split tensile strength of concrete cylinders repaired using GGBS, FA, CXP and RSAP are compared and graphically represented in Figure 8.

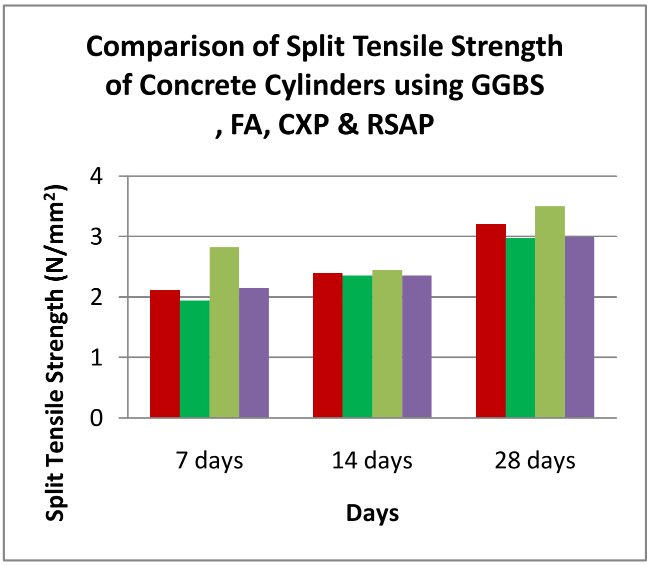

Figure 8. Comparison of Split Tensile Strength of Concrete Cylinders

CONCLUSION

- The two mineral admixtures Granulated Blast Furnace Slag (GGBS), Fly ash of F Class (FA) and two Chemical admixtures Crack X Paste (CXP) and Roff Shotcrete Acrylic Polymer (RSAP) are used to repair cracks in concrete cylinders.
- M25 grade concrete is designed and used in this investigation. The target strength is achieved.
- The repaired major straight line cracks did not reopen and the repaired cylinders failed due to formation of new major

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straight-line cracks. Arising of new cracks can be avoided when repairing is extended to retrofitting.

- Increase in Split Tensile Strength of concrete cylinders is observed. 12%, 2% and 8% increase is noticed at 7th day, 14th day and 28th day respectively when GGBS is used.
- Only minimal increase or no increase is observed when FA is used. In 7th day 3% increase, 14th day no change and 0.3% on 28th day is recorded.
- Among the two mineral admixture chosen, GGBS proves efficient in usage.
- Increase in Split Tensile Strength of concrete cylinders is observed. 16%, 17% and 19% increase is noticed at 7th day, 14th day and 28th day respectively when CXP is used.
- In 7th day 6% increase, 14th day is 3% and 3% on 28th day is recorded when RSAP is used.
- Among the two chemical admixture chosen, Crack X Paste proves efficient in usage.
- Using this type of readily available and efficient admixtures, repairing can be done at any stage of failure of concrete structures

REFERENCES

[1] E.P.Popov And V.V.Bertero,"Repaired Reinforced Concrete Members Under Cyclic Loading", Engineering And Structure Dynamics.,Vol.4, (1975),Pp. 129-144.

[2] Aravind Rajabather,"Investigation Of Cracks In Buildings"Research Gate, (2017)

[3] J.S.Ryo"An Experimental Study On The Repair Of Concrete Crack By Electrochemical Technique", (2001), Vol 34, No.7, Pp 433–437.

[4] Zamin Jumaat,Md.Humaayun Kabir And M.Obaydullah,"Review Of The Repaired Concrete Beams", Journal Of Applied Science Research, (2006) Vol.2 No.6,317-326.

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ISBN: 978-93-90214-19-8

Experimental Studies on Sugar Cane Bagasse Ash Based Materials Reinforced with Glass Fibre

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Abstract—This article describe to the outcome of investigational studies carried out on a Sugar cane bagasse ash (SCBA) based materials. SCBA is by-product produced from burning of raw sugar cane in sugar cane industry. The newly prepared materials (NPM) was prepared by mixing sugar cane bagasse ash, blast furnace slag and glass fibre (GF) as reinforcing materials with binder as ordinary Portland cement. In this present experimental study contain five different mix ratio 0.2%,0.4%,0.6%,0.8% and 1.0%. Blast furnace slag was added 10% to weight of sugar cane bagasse ash. Specimen were prepared by adding 10% ,15% and 20 cement to weight of sugar cane bagasse ash used for binding purpose. The specimen were tested under compressive loading after curing 7 days14 days and 28 days respectively. The impact of different mix percentage(ratio) on compressive strength, density and stress-strain behavior of newly prepared materials were study. The experimental result shows that density of NPM fall down with increase in percentage of glass fibre materials. The compressive strength of NPM with mix ratio 0.6% shows maximum value than other mix percentage. The stress-strain pattern was noticed to be nonlinear for all mix percentage and curing period.

Keywords—Sugar cane bagasse ash, BF slag, Compressive strength, density, glass fibre

I. INTRODUCTION

The sugarcane is main crops cultivated up in over several nations and its overall production is 1.5 trillion. In India, sugar cane production is more than 0.3 trillion /years due to 10 million tons of SCBA unutilized as garbage [10]. Bagasse is the fibrous and tough waste formation later the exclusion of the sugar cane juice from the sugar cane in sugar cane factories. Ash is a excess earned from the burning of bagasse in sugar cane manufacturing factories. The waste of SCBA is deposited in low lying areas cause heaps in that area. The effective utilization of these waste only solves its dumping problem but also gives an cheap construction material. This paper objective principally focussed on the behaviour of development of new material using waste as SCBA, BF slag and glass fibre and binder as OPC.

According to American Concrete Institute (ACI) committee, slag is non-metallic outcome[1], containing largely of silica and aluminosilicates of CaO and of other sources that is produced in a red-hot state at once with iron in a BF slag (blast furnace). This is the waste material, containing mainly of CaO, SiO2, Al2O3 and MgO, come from out of the iron making blast furnaces. It is initially in liquid form but is ultimately settled-off as a solid after cooling [5].

The glass describes to materials, generally mixes of metal oxides, mainly silica, which does not crystallize after frozen from the liquid to the solid state [8]. GF are formed in a process called fiberization in that melted glass is extracted in the form of filaments, through the bottom side of a heated platinum container [14]. Glass fibres demonstrate valuable properties such like stiffness, transparency, resistance to chemical damage and inertness, as good as proper fiber properties like strength, flexibility, and stiffness[3].

II. CHARACTERIZATION OF MATERIALS

For preparing new material sugar cane bagasse ash was reinforced with glass fibre ,Blast furnace slag and OPC. The SCBA used in the investigational study had specific gravity (G) of 1.99, from the hydrometer analysis the percentage of very fine sand was 40, slit 45 and clay 5. After standard proctor test result, maximum dry density (γd) of 0.94 g/cc and optimum moisture contain (OMC) was 20%.The density of glass fibre used in the experiment was 0.78 g/cc they were 12mm in length. The scanning electron microscope (SEM) investigation were executed to know the[14] geomorphology of Glass fibre. Figure 1 shows the photographing SEM of glass fibre.

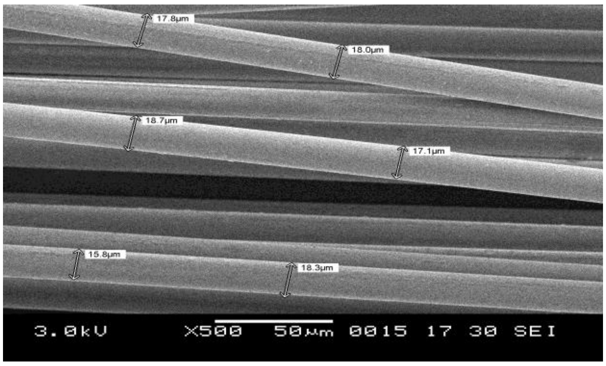

Fig. 1 Scanning electron geomorphology of glass fibre

The bulk density of glass fibre was obtained as per ISO 10119(2002) by Pychnometer method

III. EXPERIMENTAL PROGRAM

In the experimental work significance of inclusion of glass fibre as reinforcing material with different mix ratio on compressive strength, density and stress- strain pattern of NPM was studies for curing period 7 days 14 days and 28 days.

IV. MIX RATIO AND PREPARATION OF SPECIMEN

In this experimental program mix ratio is weight of glass fibre to weight of SCBA. The mix ratio are based on past [9,13] literature review. Dry weight of SCBA is find out using formula $W_{SCBA}=\gamma_{dm} \times V_{SCBA}$,where γ_{dm} dry unit weight of SCBA and V_{SCBA}.volume of SCBA , $V_{SCBA}= V-V_{BFslag} - V_{GF}$, V the total volume to specimen (1000cc), and V_{BFslag} is taken 80cc and volume of V_{GF} glass fibre is taken 2.21 to achive the mix ratio 0.2 % for cube having dimension 100mm x 100mm x 100mm.Mix proportion is define as weight of BF slag to weight of SCBA is taken 10% for the experimental work and Cement to weight of SCBA is consider 10%, 15% and 20%.

Fig. 2 Photograph of specimen failure

Dry sugar cane bagasse ash , BF-slag and cement mixed carefully to make even mass[13]. For the uniform mixture water was added gradually 50% to the weight of sugar cane bagasse ash. Afterward the adding of GF was done suitably and mixing was properly in order to avoid clumping of glass fibre.

Table 1. Different mix ratio preparation in the experiment

Mix R atio *(GF/SCBA)%*	C/SCBA %	Mix Proportation (BF/SCBA)%
0.2	10,15,20	10
0.4	10,15,20	10
0.6	10,15,20	10
0.8	10,15,20	10
1.0	10,15,20	10

V. TEST PROCEDURE

The sample were dried after curing and mass of every cube was note down using an electronics weight balance. Dry sugar cane bagasse ash, BF slag and cement were mixed carefully for uniform mass. The glass fibre were added after wet mix of sugar cane bagasse ash ,BF slag and cement .This was done to avoid lump of glass fibre together [9]. For the mixing water was added further 50% to weight of sugar cane bagasse ash. Then the mix were added into cube with support of trowel and compacted using temping rod. Compressive test was perform using compressive test machine having capacity 50kN with constant deformation rate of 1.00 mm/mit. The deformation of each specimen was measured using LVDT.

VI. RESULT AND DISCUSSION

DENSITY

The density is essential features of newly prepared materials and substantially influenced through the mix ratio and addition of GF. The effect of mix ratio on density of the NPM with distinct mix ratio is shown in figs.3(a and b). The density of NPM was observed in the range 1326.8 Kg/m^3 to 1151.0 Kg/m^3. For each mix ratio the density of newly prepared martials was decrease linearly as the mix ratio increase for each glass fibre to sugar cane bagasse ash. For all the mix ratio and for curing period the C/SCBA ratio 20% having highest density of materials than C/SCBA ratio 10% and 15%.The density of newly prepared materials smaller than traditional fill materials which is in range 2100 to 1700 kg/m^3 as reported by [7].

COMPRESSIVE STRENGTH

The compressive strength of NPM was considerably affected with the curing duration, glass fibre and mix ratio value. The three specimen for mix ratio were prepared and tested under 1.0 mm/min. The specimen were prepared for 7 days,14days and 28

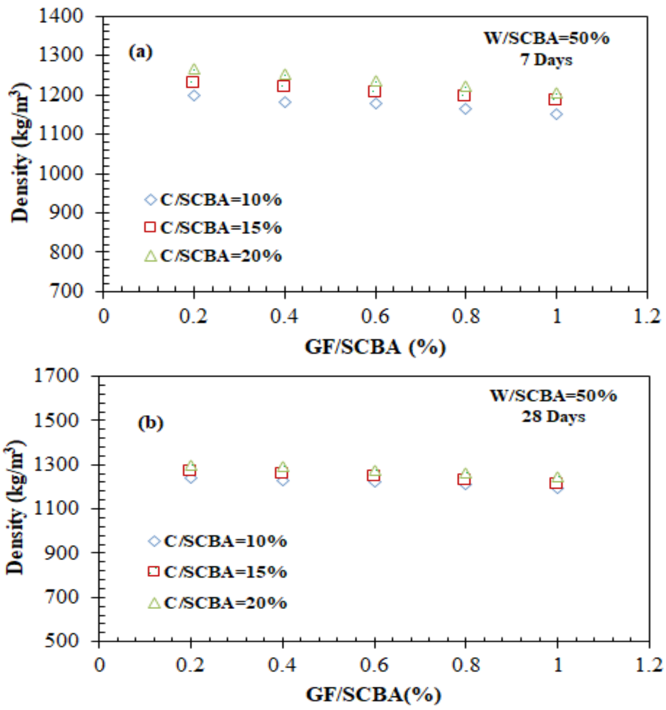

Fig. 3 Density of NPM for 7 and 28 days with respect to mix value

days curing. The maximum compressive stress with respect to maximum compressive load is characterize as compressive strength. The compressive strength of NPM observed to be improved than non-reinforcing materials with addition of glass fibre up to 0.6 mix ratio. From the figs. 4(a and b) the relation among compressive strength and mix ratio was non-linear. Comparable kind of behavior were noted by Mandal and Rathan Lal (2017) [9]and Henery and Lawrence(1979)[6]. The strength varies from 123kPa to 1061.5kPa form 7 to 28 days for cement to weight of SCBA ratio is equal to 10%,15%, 20%.The maximum compressive strength observed from 0.6% mix ratio.

STRESS STRAIN PATTERN

The compressive strength result was used to find the stress- strain features and stiffness of SCBA based materials. The effect of mix ratio on compressive stress and axial strain for GF/SCBA for 7days ,14days and 28 days curing duration for mix value 0.4 % shown in fig. 5(a, b and c).

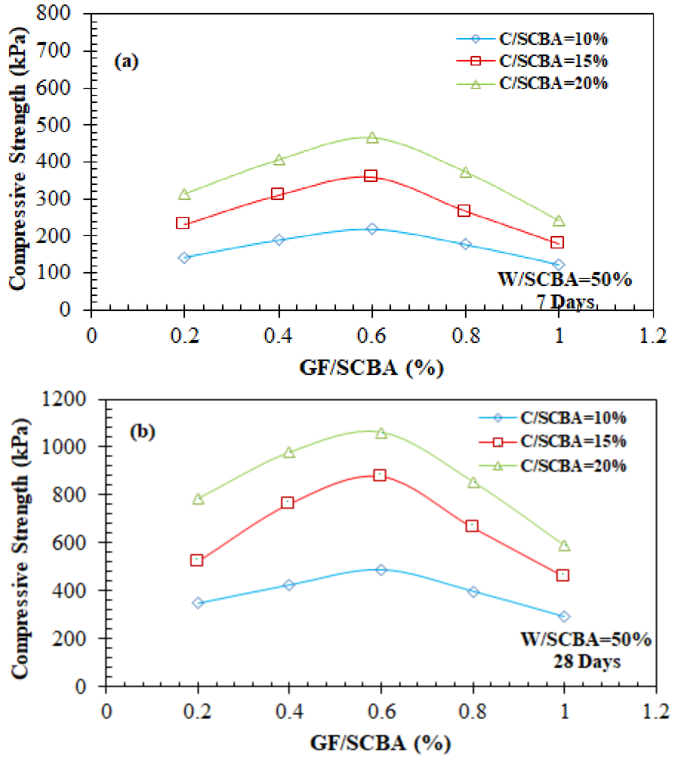

Fig. 4 Compressive strength of NPM for 7 days and 28 days with respect to mix value

For each mix ratio and curing periods, nonlinear behavior was found between compressive stress and axial strain. The compressive strength and stress-strain aspect of NPM was mostly affected by C/SCBA ratio. For C/SCBA ratio is 20% has shown greater the compressive strength than 10% and 15% for each curing period.

VII. CONCLUSION

In the experimental study, the effect of addition of Glass fibres on density, compressive strength, of the newly prepared material containing SCBA, slag and cement were investigated. A series of compressive strength tests was carried out on the material with different mix ratios, cement content, different proportion of glass fibres and curing periods.

1. The density of newly prepared material was decrease with increasing percentages of glass fibre. With addition of glass fibre in the series 0.4 to 0.8 %, the density of the newly prepared materials was decrease from 1314.8 to 1151 kg/m^3 for all GF/SCBA mix ratio value.

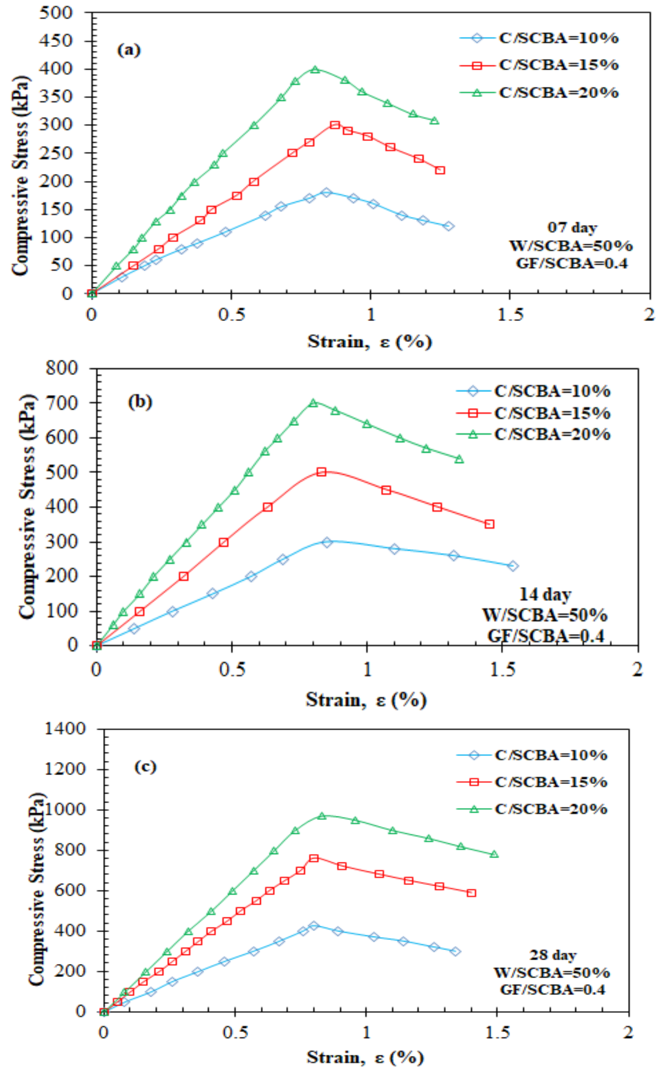

Fig. 5 Variation in stress-strain pattern

2. The compressive strength of NPM for all mix ratio and curing period were in the range 189.5 to 1061.5Kpa.
3. The NPM using C/SCBA ratio of 20% has compressive strength higher than C/SCBA ratio 15% and 10% for all mix ratio. The mix ratio with 0.6 % was higher the compressive strength than 0.4 and 0.8 % mix ratio. The compressive strength were

ISBN: 978-93-90214-19-8

significantly affected by the addition of glass fibre for all mix ratio value.

4. The compressive strength unreinforced SCBA found to be improved by reinforced with glass fibre up to 0.6% mix ratio.

5. From the stress strain curve between axial strain and compressive stress the non linear relationship were found for all mix ratio

REFERENCE

[1] ACI Committee 233. (1995). “Ground granulated blast-furnace slag as a cementitious constituent in concrete, ACI 233R-95 ”, *Report of ACI Committee 233*, American Concrete Institute, Detroit, USA.

[2] ACI Committee 544. (1996). “State-of-the-art report on fibre reinforced concrete, ACI.1R-96.”, *Report of ACI Committee 544,* American Concrete Institute, Detroit, USA.

[3] Bentur A. and Diamond S. (1986). “Effect of ageing of glass fiber reinforced cement on the response of an advancing crack on intersecting a glass fibre, strand”, *The International Journal of Cement Composites and Lightweight Concrete*, 8(4), 213-222.

[4] Indian Mineral Yearbook 2014 (Part-II Metals & Alloys), “Slag iron and steel” *Government of India, Ministry of Mines and Indian Bureau of Mines*, 53rd edition, Indira Bhavan, Civil Lines, Nagpur 440 001.

[5] IS: 10447-1983, “Guidelines for utilization and disposal of solid wastes from integrated steel plants”, *Bureau of Indian Standards*, New Delhi, India.

[6] Henry, N.M. and Lawrence,L.C.(1979).Glass fibre reinforced cement base materials, Fibre Reinforced Concrete,44(14):247-264.

[7] Liu H.L.,Deng A.and Chu J. 2006. Effect of different mixing ratios of polystyrenes pre-puff beads and cement on the mechanical behavior of lightweight fills, Geotextiles and Geomembranes,24,331-338.

[8] Lyons A. (2010). “Materials for architects and builders”, 4th Ed., Elsevier, Hong Kong, China, pp. 420.

[9] Mandal D. and Ram Rathan Lal B. (2017). “Compressive Strength Behavior Glass Fibre Reinforced Furnace Slag- Based Materials”, *Indian Geotechnical Conference GeoNEst, IIT 14-16 December,* Guwahati, India.

[10] Modani P.O., Vyawahare M. R. (2012). “ Utilization of Bagasse Ash as a Partial Replacement of Fine Aggregate in Concrete”, *International Conference Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University,* 25-29.

[11] Song Ha-W. and Saraswathy V. (2006). “Studies on the corrosion resistance of reinforced steel in concrete with ground granulated blast-furnace slag-an overview”, *Journal of Hazardous Materials*, B138, 226-233.

[12] Ram Rathan Lal B.,Hinge V.A.,Nawkhare S.S.,Shankar K.(2019). “Experimental Studies on Bottom Ash and Blast Furnace Slag Based Geomaterial under Compressive Loading”, *Geotechnical Congress*

[13] Ram Rathan Lal B. and Badwaik V.N. (2016). “Experimental Studies on Bottom Ash and Expanded Polystyrene Beads-Based Geomaterial”, *Journal of Hazardous, Toxic and Radioactive Waste,* 20(2), 2016.

[14] Ram Rathan Lal B.,Nawakhare S.S.(2016). “Experimental Study on Plastic Strips and EPS Beads Reinforced Bottom Ash Based Materials”, *International Journal of Geosynthetics and Ground Engineering*,1-12.

[15] Wallenberger F. T., Watson J. C. and Li H. (2001). “Glass fiber”, *ASM Handbook*, 21, 27-34.

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ISBN: 978-93-90214-19-8

The Effect of Topography on Settlement Patterns in The Nusa Penida Island, Bali, Indonesia

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Abstract— Nusa Penida Island's physical condition is an area with dry, calcareous, and steep topography, valley also hilly. Nusa Penida Island consists of 16 villages scattered in clusters in the northern and southern regions with coastal and hilly areas. The settlements in the south of the part have an organic settlement pattern following the pattern and height also the type of soil from the topography of the area. This research aimed to examine the topographical aspects of villages' settlement patterns in the southern part of Nusa Penida Island. The method used in this research is qualitative content analysis through an approach to the content aspects of studies on Nusa Penida, empirical conditions, and aerial photography analysis. The sample selection was limited by purposive sampling to two villages, namely Tangled Village and Batukandik Village. The results of this study indicate that there is a harmonious and integrated relationship between settlements and land: (1) the zone of worship (shrines/temples) and residential zones of houses; (2) rocky soil type as an option in residential construction; (3) soil layer with minimal rock content as an alternative to agricultural land; and (4) have an organic settlement pattern.

Index Terms— ***land harmonization, land hierarchy, organic settlement patterns, Nusa Penida Island, topography*.**

I. INTRODUCTION

The vernacular settlement pattern is generally influenced by the natural conditions in which the settlement is located [1]–[4]. The natural conditions in focus are the topography, the formation of the building mass, and the building mass's orientation, which adapts to the context of its physical environment. Vernacular communities' settlement culture focuses more on the aspects of the response to the physical environment and local climatic conditions [5]–[7]. This condition causes the architectural formation to be simple and uniform, also with a simple layout. The simplicity of vernacular architectural layout can be divided into two, namely a zone for shrines and a zone for residential dwellings. This context is more prevalent in vernacular settlements on Bali's island, with a strong ancestry concept, thus distinguishing between residential and worship zones [8], [9]. Unlike the vernacular architectural settlements outside Bali's island within the archipelago, the place of worship becomes an integral part of the traditional house [10]–[12]. The sacred space position is placed at the top of the building level, and the human dwelling is at the bottom of the building. The course has a different character from that in Bali. The difference in zoning arrangements is very clearly visible in the residential spatial layout of a residential house. This difference is physically indicated by the height of the land in the vernacular settlement.

The hierarchy of vernacular settlement spaces in Bali is manifested in spatial layouts with different levels of land. The land hierarchy utilizes topography for planning zones for worship and zones for residential dwellings. This phenomenon can be found in the settlement of the people from the southern island of Nusa Penida. Nusa Penida has a dry, hilly valley and calcareous landscape [13]–[20]. People's understanding of the relationship between humans and their creators is interpreted in the settlement layout by placing the worship zone on a higher contour than the residential zone for the residence. Even though the settlement pattern is organic following the direction of contour lines and adjustment to flat land, Nusa Penida's people position them more primarily on high contours. The differs from vernacular settlements in general. It has a clearer and more regular also uniform sacred and profane orientation. Apart from the spatial hierarchy, topography's influence also affects land selection for residence and dryland agricultural land. Land for settlement is chosen on rocky soil to reduce deep foundations and soil stability when an earthquake occurs, and agricultural land on soil with minimal rocks.

The culture of living on the island of Nusa Penida, which is influenced by topographical conditions, is a fascinating research study. There are no studies on vernacular settlement architecture that discuss the correlation between topographic conditions that affect settlement patterns - its shape, orientation, and zoning arrangement. So far, studies have focused more on the cosmology of vernacular architecture, namely (1) studies of vernacular settlements on spatial planning. [9], [21], [30], [31], [22]–[29]; and (2) vernacular settlement patterns are based on life-giving places such as lakes, seas, or rivers [32]–[34]. While the study on the influence of topography towards the pattern of vernacular settlement has never been studied.

This study was aimed to identify the influence of topography on the architectural spatial pattern of community settlements in Nusa Penida Island. The spatial pattern in focus was the building mass's shape, the building mass's orientation, and the zoning system. This research case was selected in the settlements of the people of Nusa Penida Island in the south. The selection of this case was by purposive sampling by considering (1) the condition of the area in Nusa Penida in the southern part, which is hilly, valley, and calcareous with various contours; (2) has an organic settlement pattern that can be seen from the morphology of the settlement; and (3) have a history as indigenous villages in Nusa Penida. The selected cases were in Tanglad Village and Batukandik Village. The two villages are enough to represent in answering the research objectives.

The research method used is qualitative content analysis [35], [36] through the approach of (1) literature review of vernacular settlement architecture in Indonesia; (2) an observational study of the physical condition of the selected cases; (3) contour studies using visual aerial photographs; (4) research results on the history, social, culture, and physical condition of Nusa Penida Island. This study illustrates the effect of topography on the formation of residential spatial planning in Nusa Penida Island. These influences are the structure of the building mass, the building mass's orientation, the selection of land for the zone of worship and residence, and agriculture.

II. Research Methods

The research focus is on Nusa Penida's island, separated by the sea from Bali's island in Indonesia. Nusa Penida Island's characteristics are calcareous, dry, valley and hilly and have several villages scattered in clusters [13]–[20]. This location's characteristics were the reasons for choosing Nusa Penida Island as the study of this research. There are 16 villages on Nusa Penida Island divided into two areas: the northern and southern regions. The sample selection was purposive sampling in two villages located in the south part of the island of Nusa Penida, namely Tanglad Village and Batukandik Village (see Figure 1). These two villages' choice was based on the village's status, including the ancient town in Nusa Penida and having unique characteristics of building mass patterns, namely organic. The study's focus in this research is the Nusa Penida community's settlement pattern in the context of building mass structure, orientation layout, and culture in choosing land for places of worship, residential housing, and agricultural land.

The research method used is descriptive qualitative content analysis [35], [36]. This method emphasizes the content meaning of the spatial phenomena of the Nusa Penida community settlement. To analyze content on empirical phenomena, research results, and contour studies through the following research steps: (1) literature study on vernacular settlement spatial planning to determine the development of vernacular research focus; (2) conducting an initial grand tour study on the settlement layout of Nusa Penida Island; (3) finding the gap on the locus and focus of the study; (4) contour studies to identify trends in the settlement arrangement of the Nusa Penida community; (5) coding the results of observations and studies that have been done; (6) triangulating the content produced; and (7) drawing interpretive conclusions.

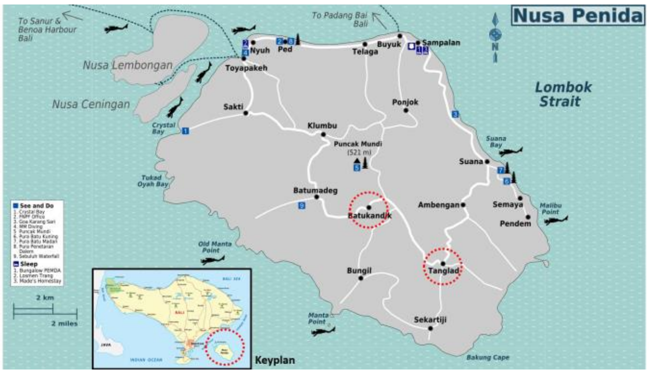

Figure 1. Locus of Research; Tanglad and Batukandik Villages, Nusa Penida

III. Results and Discussion

A. Overview of Nusa Penida Island

Nusa Penida's island consists of 16 villages scattered on the dry, calcareous valley and hilly land. The distance between one town and another is far apart, divided into two parts, namely villages located in the coastal area or the northern part of Nusa Penida Island and villages that occupy the southern part of Nusa Penida [13]–[20]. People who live in the northern part of Nusa Penida Island are generally immigrants from villages in the southern region of Nusa Penida and residents from other areas outside of Nusa Penida Island. According to archaeological and anthropological studies, during the period of the Klungkung kingdom and other kingdoms on Bali's island, the island of Nusa Penida became an island of exile for perpetrators of such crimes. [15], [19]. The means, the inhabitants of Nusa Penida Island are from the indigenous population and those who came from exile due to when Nusa Penida became part of the Klungkung Kingdom.

ISBN: 978-93-90214-19-8

Nusa Penida has the characteristics of a hilly and valley area which affects the aspects of its settlement. The northern part of Nusa Penida has the character of a coastal area with a sloping contour or topography, and the southern part is a hilly area (see Figure 2 and 3). The topography colours the existing conditions of the villages on the south part of Nusa Penida Island. Usually, the southern towns of Nusa Penida have an organic mass pattern following the contour shape and topographic height. The characteristics of the land that are rocky, calcareous, dry, and contoured affect the villages' physical conditions in the southern part of Nusa Penida. Residential houses fill flat ground between the contour's elevation, and agricultural land tends to occupy steep contoured land that is not rocky. The contour's height forms the basis for residential spatial planning, consisting of three zones, namely places of worship, residential areas, and agricultural land.

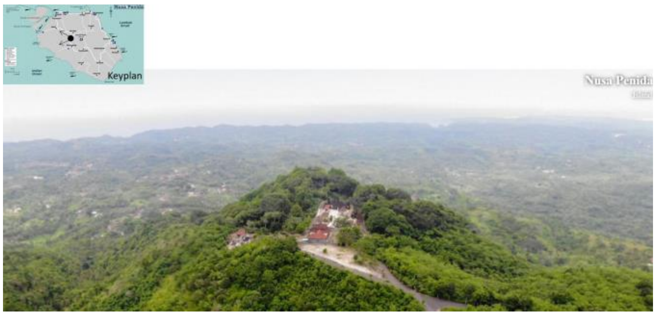

Figure 2. The Highest Contour in Nusa Penida is The Puncak Mundi Temple Area

Figure 3. Topographic View of Nusa Penida Island from The South

B. Selection of Flat Land as a Place to Construction Buildings

Nusa Penida Island's topography, which is hilly and sloping, has caused the community to choose relatively flat land as a place to build houses. The availability of mostly flat land is still minimal so that the flat land has a variety of shapes and distances between lands. Each family member can choose ground according to the house's designation; each home has a different form according to the land condition. Distance variants between one place and another were found due to irregular repetition of the distance between contours. In one village, it has various shapes and varying contour elevations.

In contrast to settlements in other areas in Bali, the land for settlements is widely available. The spatial arrangement of concessions will be more comfortable and have a clear pattern. For example, the territory of the Atoni tribe, the Tamkesi village on Timor Island, is a highland settlement that has varied contours in terms of elevation, availability of flat land for development, and rocky geological layers [37].

The first case was in Tanglad Village. The settlement pattern of Tanglad Village is organic following the contours (see Figure 4). Residential building configuration patterns vary and follow the contour line movement. Each residential land has varying heights, so to move from one house to another, you must pass different land sizes. The highest point of Tangglad Village is at the significant intersection or *Catuspath*a; then the pattern flows down each contour line forming an organic design. According to Wijaya (2019a), *Catuspatha* (village centre) has a function as a ritual space for renewal at the village level and as a symbolic "space of balance." This space occupies high topographical land under residential land. The movement of settlement development is towards the south because the land and area with a relatively large percentage are south. Therefore, the community's method and perception in determining where to live are looking for land that is relatively flat and easy to access. The has an impact on the mass orientation of the building following its contour formation.

Apart from Tanglad Village, another village in the southern part of Nusa Penida is Batukandik Village (see Figure 5). The settlement pattern is similar to that of other village settlements in that it follows the contour's course and height organically.. The settlement is in the southern part of an area lower than the village's grand intersection point. The pattern that can be seen clearly in selecting flat land in this village is that the highest land becomes a zone for a shrine or temple on a village scale, while the settlements are on the lower contour. So, it can be concluded that selecting a flat contour as a factor in determining the place or land to build starts from an area with a lower contour elevation. Simultaneously, the higher areas are designated for the function of a holy place or temple. The studies about God and Ancestor as the highest aspect [9], [21], [30], [31], [22]–[29], to the empirical understanding of logic by the people of Nusa Penida in constructing buildings on contoured land is translated in the context of belief and cosmology of the Creator. As the highest aspect in topographic layout, God gets the most elevated land embodied in a worship building or sanctuary (temple).

C. Rocky land as an option in constructing buildings

Nusa Penida Island has a long distance from the Bali Plains, which are separated by the sea. Before Nusa Penida's island became an exile area by the kingdoms in mainland Bali, engineering knowledge was still not much exploring nature;

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humans were adjusted to their existing conditions. The technology in building houses and shrines is not like today's, more contemporary, be it architecture or construction. This choice was based on the ease in building, especially installing the building foundation. Because the rocky land does not require a certain depth like a contemporary building, it only takes a notch on the shaky ground to stand up well. Land that has minimal rocky character is used as dry land or dryland agriculture. According to Ferdeanty, Sufardi, & Arabia, (2020), rocky soil has a strong binding ability and capacity against loads. Moreover, the type of house on Nusa Penida's island is still relatively simple, so it is not too large.

The settlement in the southern part of Nusa Penida has a rocky land character. Rocky land for constructing buildings and land with little rock content for agriculture. In Tangglad Village, the shaky ground is used for residential areas, but the contours are irregular. Agricultural land tends to be in the southern part of the village and has many contour lines. Land with minimal rocky soil is productive in the planting medium compared to the shaky ground. The rocky land takes longer for the plants to grow and develop. So that land with rocky character becomes an option to build a building (a holy place or a house). The same thing is also found in Batu Kandik Village, which has a linear settlement pattern. In this village, the land used for constructing buildings is rocky, while those that are relatively flat or contoured and have land with minimal rocks are used as a productive place for farming (see Figure 4 dan 5).

D. Settlement Patterns Follow Contour Forms

Nusa Penida's island has hilly land, a valley and dry [15], [19]. This condition causes Nusa Penida Island to have land with many contour lines, forming hilly heights. It isn't easy to get comprehensive and flat land, except for Nusa Penida Island's settlement in the north or the coast. The flat land was not found in large areas but segments. Therefore, settlement patterns appear to spread out and follow the direction of movement or contour curves that look more organic. Unlike the mountainous settlements in mainland Bali, where the linear pattern is more precise, the settlement forms are uniform. According to Putri, Gunawan, & Arifin (2013) and Wijaya et al. (2018), settlements located in contoured areas that still pay attention to the natural environment's context have an organic pattern following the curves of the contour lines.

The Tanglad and Batukandik villages' settlement pattern is organic, following the contour (see Figure 4 dan 5). The village's main road gives the direction of movement of the settlement pattern and as a binding settlement on the road's left and right. Each settlement cluster has a different settlement shape depending on the form of the contour line. The consistency of one building's direction and position is not compact but has body and approach. A clear pattern is the high contour section allocated for the sanctuary or temple area, while the low contour is issued for residential buildings. The idea is based on the vernacular and common perception of the high lands (hills or mountains) as the gods' home and ancestral spirits, with worship taking place there. [9], [21], [30], [31], [22]–[29]

E. Hierarchy of Land

The architecture of vernacular settlements usually has a hierarchy of space divided into two sacred and profane zones. Religious zones are identified as worship and secular areas in residential housing [8], [9]. Cosmology is, of course, interpreted in a scientific context as a natural condition in the form of topographical conditions and the concept of belief in everything that is "main" or "great" (God or Ancestor). God or Ancestor becomes the orientation of vernacular society in its spatial structure as a form of the human relationship with its Creator. If it is correlated with the culture of living regarding land selection for development, the "main" one is placed in the best position, such as higher land [26].

This phenomenon occurs in the vernacular settlements' spatial layout on Nusa Penida's island with hilly and valley natural conditions (see Figure 4 dan 5). Two cases in this study indicate that the contours of the topography influence settlement patterns. In zone selection, the highest outline tends to build shrines as the main or great part, and the residential dwellings are in the lower zone against the worship zone. They are respecting and maintaining the sacredness of a place of worship from a secular or profane context. Following Eliade (1957) statement, this sacred value is that the holy atmosphere can be maintained through its management. In this context, management is placing a shrine on land that is higher than the surrounding land.

Figure 4. Tanglad Village Settlement Pattern, Nusa Penida: (a) flat and rocky land for residential housing; (b) higher land than its surroundings; (c) contoured land for agriculture

ISBN: 978-93-90214-19-8

Figure 5. Batukandik Village Settlement Pattern, Nusa Penida: (a) flat and rocky land for residential housing; (b) higher land than its surroundings; (c) contoured land for agriculture

CONCLUSION

The community settlement pattern in Nusa Penida has an organic design with contours as a basis for consideration in building a settlement. This organic pattern is a consequence of land use with a hilly topographic character and is flat and lacks a large amount of flat land. The local wisdom of the people of Nusa Penida in applying a culture of living following the land context through an attitude of harmony with the land conditions. Harmonization and integration between settlements with the context of the hilly and sloping ground by (1) using rocky land as a place to build residential dwellings to facilitate the construction of building foundations; (2) choosing land that has minimal rocks and tends to be on flat, contoured land; and (3) placing shrines or shrines on a higher contour towards residential land that is secular.

REFERENCES

[1] G. D. Carlos, M. R. Correia, S. Rocha, and P. Frey, *Seismic Retrofitting: Learning from Vernacular Architecture*. CRC Press, 2015.

[2] I. Mentayani and P. R. Muthia, "Menggali Makna Arsitektur Vernakular: Ranah, Unsur, dan Aspek-Aspek Vernakularitas," in *Temu Ilmiah Ikatan Peneliti Lingkungan Binaan Indonesia 6*, 2017, pp. I109–I116.

[3] S. Roaf, "Lessons from vernacular architecture," *J. Archit. Conserv.*, vol. 20, no. 1, pp. 67–68, Jan. 2014.

[4] D. Whelan, "Built to meet needs: cultural issues in vernacular architecture - By Oliver, Paul," *J. R. Anthropol. Inst.*, vol. 16, no. 1, pp. 165–166, Mar. 2010.

[5] I. J. Gil Crespo, M. M. Barbero Barrera, and L. Maldonado Ramos, *Vernacular Architecture: Towards a Sustainable Future*. CRC Press, 2014.

[6] B. Kırbaş and N. Hızlı, "Learning from Vernacular Architecture: Ecological Solutions in Traditional Erzurum Houses," *Procedia - Soc. Behav. Sci.*, vol. 216, pp. 788–799, Jan. 2016.

[7] A. Rapoport, "Vernacular architecture and the cultural determinants of form.," *Buildings and society*. 1984.

[8] I. K. M. Wijaya, "Study of Orientation of Kaja and Kangin Cosmology on Village Pinggan Settlement," in *Exploring theVillage of Pinggan*, Denpasar: Satria Aksara, 2019.

[9] I. K. M. Wijaya, "Effect Local Direction on Balinese Traditional Settlement Layout , Case Study : Pengotan Traditional Village in Bali , Indonesia," *Civ. Eng. Archit.*, vol. 8, no. 6, pp. 1395–1407, 2020.

[10] D. A. Amabi and T. K. Dima, "Pengaruh Ritual Adat Terhadap Tata Ruang Permukiman Tradisional Suku Matabesi Di Kabupaten Belu," *Gewang Gerbang Wacana dan Ranc. Arsit.*, vol. 2, no. 1, pp. 9–15, 2020.

[11] C. Nuraini, A. Djunaedi, Sudaryono, and T. Y. W. Subroto, "Bincar-Bonom as the basis of house formation in Singengu village settlement," *J. Sci. Res. Stud.*, vol. 1, no. 4, 2014.

[12] Y. Sumalyo, "Kosmologi Dalam Arsitektur Toraja," *Dimens. (Jurnal Tek. Arsitektur)*, vol. 29, no. 1, pp. 64–74, 2001.

[13] I. M. Geria, "Unsur Budaya Bali Selatan di Nusa Penida, Kajian Seni Arca Masa Klasik," *Forum Arkeol.*, no. 2, 1997.

[14] B. J. Haga, "Adatproces op Noesa Penida," in *Adatrechtbundels XXIII Java en Bali*, 's-Gravenhage: Nijhoff, 1924.

[15] K. Helbig, "Noesa Penida, Het 'Bandieteneiland,'" in *Tropisch Nederland, Veertiendaags Tijdschrift ter Verbreiding van Kennis omtrent Nederlandsch Oost- en West-Indië*, X. Jaargang, Ed. Amsterdam: Uitg.J.H.de Bussy, 1939.

[16] C. Holt, "'Bandit Island' A Short Exploration Trip to Nusă Penidă," in *Traditional Balinese Culture*, J. Belo, Ed. Columbia University Press, 1970, pp. 67–84.

[17] V. E. Korn, "Noesa Penida," in *Cultureel Indie*, Leiden: E.J.Brill, 1994.

[18] C. Muller, *Nusa Penida, an adventure*. Walsh Bay Press Sydney, 1990.

[19] I. B. Sidemen, "Penjara Di Tengah Samudra: Studi Tentang Nusa Penida Sebagai Pulau Buangan," in *Seminar Sejarah Lokal*, 1984.

[20] I. K. M. Wijaya, I. N. W. Paramadhyaksa, and N. K. P. D. Jayanti, "Pola Permukiman Desa-Desa di Pulau Nusa Penida, Bali," in *Prosiding Temu Ilmiah IPLBI 2018*, 2018, pp. 031–037.

[21] N. K. A. Dwijendra, *Arsitektur rumah tradisional Bali: berdasarkan asta kosala-kosali*. Denpasar: Kerjasama Bali Media Adhikarsa [dengan] Udayana University Press, 2008.

[22] N. K. A. Dwijendra, *Arsitektur & kebudayaan Bali kuno*. Denpasar: Kerjasama CV. Bali Media Adhikarsa [dan] Udayana University Press, 2009.

[23] N. K. A. Dwijendra, "From tradition to modernization in morphological process of indigenous settlement patterns in Bali, Indonesia," *Int. J. Adv. Sci. Technol.*, vol. 29, no. 8, pp. 856–868, 2020.

[24] H. S. Nordholt, "Custodians of the Sacred Mountains: Culture and Society in the Highlands of Bali," *J. Soc. Issues Southeast Asia*, vol. 19, no. 1, pp. SJ19-1h, Apr. 2004.

[25] A. W. Purwantiasning, "Benang Merah Terbentuknya Pola Permukiman dan Pola Hunian Desa Bali Mula Dikaitkan dengan Aspek Sosial, Ekonomi dan Budaya (Studi Kasus: Desa Pekraman Julah, Kecamatan Tejakula, Bali)," *J.*

Nalars, vol. 17, no. 1, 2017.

[26] T. A. Reuter, *Custodians of The Sacred Mountains*. Jakarta: Yayasan Obor Indonesia, 2005.

[27] T. A. Reuter, *Rumah Leluhur Kami*. Jakarta: Yayasan Pustaka Obor Indonesia, 2018.

[28] Sudiro, "Legenda dan Religi sebagai Media Integrasi Bangsa," *J. Hum.*, vol. 13, no. 1, 2001.

[29] L. Vinet and A. Zhedanov, "A 'missing' family of classical orthogonal polynomials," *J. Phys. A Math. Theor.*, vol. 44, no. 8, p. 085201, Feb. 2011.

[30] I. M. J. Waisnawa, "Pola Ruang Sanga mandala Sebagai Konsep Ekologi Dalam Penataan Rumah Tinggal Tradisional Bali," in *Agama, Adat, Seni dan Sejarah Di Zaman Milenial*, 2018.

[31] I. K. M. Wijaya, "The Local Wisdom Study of Luan And Teben Concept on Balinese Ethnic Houses (Case Study: Balinese Ethnic Houses in Denpasar, Bali)," *Local Wisdom J. Ilm. Kaji. Kearifan Lokal*, 2020.

[32] A. Akil and W. W. Osman, "Bugis local wisdom in the housing and settlement form: An architectural anthropology study," *Lowl. Technol. Int.*, 2017.

[33] G. Ammarell, "Bugis Migration and Modes of Adaptation to Local Situstions," *Ethnology*, vol. 41, no. 1, p. 51, 2002.

[34] A. Mulyati, N. Soewarno, A. Ronald, and A. Sarwadi, "Spatial Characteristics of Aquatic Vernacular Settlements in Central Sulawesi (Karakteristik Spasial Permukim-an Vernakular Perairan Di Sulawesi Tengah)," *J. Mns. dan Lingkung.*, vol. 23, no. 1, 2016.

[35] C. M. Giannantonio, "Content Analysis: An Introduction to Its Methodology (2nd ed.).," *Organ. Res. Methods*, vol. 13, no. 2, 2010.

[36] K. Krippendorff, "Reliability in Content Analysis.," *Hum. Commun. Res.*, vol. 30, no. 3, pp. 411–433, Jul. 2004.

[37] R. Ch. Lake, "Tata Spasial Arsitektur Tradisional Suku Atoni di Kampung Tamkesi Pulau Timor (Traditional Spatial Architecture of the Atoni Tribe in Kampung Tamkesi, Timor Island)," *ATRIUM - J. Arsit.*, vol. 2, no. 1, 2016.

[38] I. K. M. Wijaya, "Konsepsi Natah dan Lebuh sebagai 'Ruang Keseimbangan' dalam Arsitektur Tradisional Bali," *J. Arsit. Zo.*, vol. 2, no. 2, 2019.

[39] F. Ferdeanty, S. Sufardi, and T. Arabia, "Karakteristik Morfologi dan Klasifikasi Tanah Andisol di Lahan Kering Kabupaten Aceh Besar," *J. Ilm. Mhs. Pertan.*, vol. 4, no. 4, pp. 666–676, Mar. 2020.

[40] Y. Y. Putri, A. Gunawan, and N. H. S. Arifin, "Kajian Lanskap Permukiman Tradisional Masyarakat Lampung Saibatin di Pekon Kenali, Lampung Barat," *J. Permukim.*, vol. 8, no. 3, 2013.

[41] M. Eliade, *The Sacred and The Profan*. New York: Harcour, Brace and Word, Inc, 1957.

AUTHORS PROFILE

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Badung Regency, Bali-Indonesia; (10) The Value Of Catuspatha As A Public Space For The Balinese Community In The Klungkung City, Bali Indonesia: The Struggle For Activities Between Politics, Economics And Socio-Culture; (11) The Meaning Of Local Culture Elements And Urban Elements As Forming The Identity Of The Klungkung Urban Area, Bali, Indonesia; and (12) Catuspatha As A Landmark Of Semarapura City In Terms Of Physical And Socio-Cultural Aspects.

Ngakan Ketut Acwin Dwijendra, founded on June 3, 1971, in Bangli Bali, is a lecturer of architecture at Udayan University's Faculty of Engineering's Doctoral Study Program Engineering. He has expertise as an architect, designer, city designer, researcher, book writer, and yoga teacher. He completed his Bachelor of Architecture Engineering in 1996 at Udayana University, earned a Master of Arts degree in 1999 at Erasmus University, Rotterdam Netherlands and a Philosophy of Doctor degree in 2014 at Curtin University, Perth, Australia. As a lecturer and researcher since 1997 at Udayana University, has joined the Indonesian Lecturers Association (ADI), published 19 books in the fields of Balinese architecture, housing, art, design, history and culture (11 books have been copyrighted), and active as reviewers and authors of articles in print media, proceedings seminars and international journals indexed. The national and international book publications are (1) Arsitektur Bangunan Suci Hindu pada tahun 2008; (2) Arsitektur Rumah Tradisional Bali berdasarkan Asta Kosala Kosali pada tahun 2008; (3) Arsitektur Kebudayaan Bali Kuno pada tahun 2009; (4) Tokoh Arsitek Dunia dan Karyanya pada tahun 2009; (5) Arsitektur Tradisional Bali di Ranah Publik pada tahun 2010; (6) Babad Ksatria Tamanbali Mengenal Leluhur Warih Mahagotra Tirta Harum pada tahun 2011; (7) Arsitektur dan Tata Ruang Pelabuhan di Bali pada tahun 2012; (8) Affordable Housing Provision Projects in Bali, Indonesia: Improving Quality and Cultural Acceptability pada tahun 2014; (9) Keunikan Desa Trunyan pada tahun 2015; (10) Konservasi Arsitektur Bangunan Pusaka di Kota Denpasar pada tahun 2016; and (11) Arsitektur Kawasan Pusaka di Bali pada tahun 2017. International journal publications indexed among others (1) From tradition to modernization in morphological process of indigenous settlement patterns in Bali, Indonesia; (2) Innovative work behaviours in pharmacies of Indonesia: Role of employee voice, generational diversity management and employee engagement; (3) Identity struggle perspective in the car-shaped shrine in Paluang temple, Nusa Penida Bali, Indonesia; (4) Meru as a Hindu sacred building architecture with a high roof and resistant to earthquakes in Bali, Indonesia; (5) Analysis of symbolic violence practices in Balinese vernacular architecture: A case study in Bali, Indonesia; (6) Visual exploration using acrylic paint on used fashion items for sustainable use; and (7) How traditional Balinese houses can adjust and cater for international tourism in the Canggu Area, Bali Indonesia?

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Review on Aspects of Pre-Engineered Building

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Abstract— ***In the present world urbanization is increasing rapidly. Now a day's basic requirements of construction are the best aesthetic look, economical, best quality, and time of construction. A Pre-engineered building is the best option for all these requirements. Pre-engineered buildings are cost-effective and time-consuming as compared to other technologies in construction also PEB is more sustainable and stands in top position. The execution of the pre-engineered building may be a recent concept during which utilizing the steel structure and optimizing the planning by ensuring economical integrity. In this paper, a study of literature is reviewed to understand the concepts of PEB and many advantages related to PEB steel structure.***

Index Terms— ***Pre-engineered building, Parameters***

I. INTRODUCTION

In the present world, technology has greatly improved over the years thereby contributing tremendously to improving the living standards through various new products and services. Pre-engineered buildings (PEB) are one such revolution. They use a set stock of raw materials that have been tested over time to meet a wide range of identification for structural and architectural design.

Nowadays steel industry is growing rapidly. The construction industry has discovered, invented, and developed many technologies, systems, and products, one of them being the concept of pre-engineered buildings as stated by [1]. It is easy to tie in these buildings and has proved efficient in terms of durability and strength as concluded by [2]. Aesthetics, quality, the speed of construction, cost, effectiveness, and innovation are the factors that govern the choice of the building as confirm by [3].PEB can be fitted with different structural associates as well as mezzanine floors, canopies, fascia, interior partitions, etc. as stated by [4]. PEB is distributed as complete finished products from the site. A single supplier with attached factory consisting of cladding and roofing components with a basic steel structure as confirmed by [5]. PEB buildings can be separated with all the necessities like cranes level floors and high elevations can be constructed as concluded by [6].

In the past, significant research has been done on the detailing parameters and performance of PEB, which are used for the construction of PEB frames. For instance, [7] concluded that the design project on exclusiveness in the economics of a steel building using tapered steel sections. They used a few techniques and different tapered steel sections to obtain economic sustainability in a most advantageous quantity. Also, they presented a combined study of PEB and CSB.

Comparison between the design procedure of PEB and CSB steel buildings. Besides, they concluded that PEB structures are more advantageous than CSB structures in Terms of cost influence, quality control, construction speed, and simplicity in raise. This paper also imparts simple and Economical ideas on preliminary design concepts of PEBs as stated by [8].

The review focuses the results obtained by researchers on the Pre-engineered buildings comparison with conventional steel building in terms of optimized cost and time. The purpose of this review is to understand the concept of PEB, study design procedures of PEB, and different parameters of PEB to optimizing the cost and time of construction.

PRE-ENGINEERED BUILDING

In civil engineering, pre-engineered buildings (PEBs) are designed by a PEB contractor or PEB supply creating the most appropriate account of raw materials that can be from all sources and methods Capable of conforming to structural and visual design requirements as stated by [5]. It is very advantageous over traditional buildings and is useful within the low-rise building design. The excavation to occupation no other building system matches pre-engineered building system when it involves speed and price as confirmed by [9]. Pre-engineered Buildings have bolted connections and hence can also be reused after demolition. Thus, pre-Engineered buildings can be displaced and expanded as per the requirements in the future as stated by [6].

 ISBN: 978-93-90214-19-8

Fig. (a) Pre-Engineered Building [7]

Features of Pre-Engineered Buildings

[9] Concluded that the complete building system is Pre-engineered to facilitate simple production & assembly on site. As the construction of these buildings takes minor time, Pre-engineered buildings save a great amount of labor cost. These buildings can be installed at the client's site, within a limited duration of time with fewer labor hours.

Advantages of Pre-engineered building

Following are the various advantages of pre-engineered building:-

- **Construction Time**

Buildings are generally constructed in just 6 to 8 weeks after confirmation of drawings stated by [10,14]. This allows faster lease and earlier realization of revenue. This is one of the main profits of using Pre-engineered buildings as confirmed by [3].

- **Quality control**

[11] Confirmed that the availability of certified material from steel mills having guaranteed strength and welding of the entire building components facilities undisputed quality control.

- **Lower Cost**

Systems approach, considerable saving is achieved in design, manufacturing, and erection cost as stated by [10].

- **Erection**

[12] Confirmed that all the connections of the different components are standard and the erection time is faster.

- **Low Maintenance**

PEB Buildings have high-quality paint systems for cladding and steel to suit vast conditions at the site, which in turn gives long durability and low maintenance coats as stated by [13].

- **Large Clear Spans**

Buildings can be supplied to around 90M clear spans as confirmed by [11].

Disadvantages of PEB

Following are the various disadvantages of pre-engineered building:-

- **Susceptible to Corrosion**

If not properly maintained the steel frames are vulnerable to corrosion, thus special coatings become necessary to resist the corrosion of steel.

- **Low Thermal Resistivity**

Steel being a metal is sweet at conducting heat, thus it reduces the thermal comfort in the building.

- **Low Fire Resistance**

During the fire, this type of building becomes more susceptible to damage due to its conductivity as concluded by [15].

II. COMPONENTS OF PEB

Following are the major components of the pre-engineered building:-

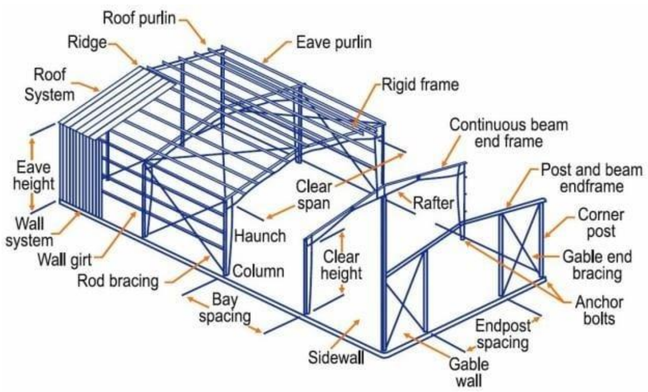

Fig. (b) Components of Pre-Engineered Building [7]

PRIMARY MEMBERS

A PEB is the primary load-bearing membrane and typically consists of the most important rigid frame. The primary members of vertical members are called columns as well as horizontals members are called rafters. [16] Concluded that the primary members erect made with hot rolled plates.

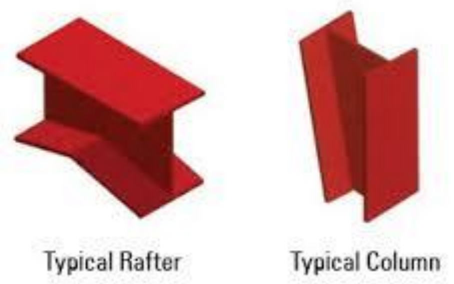

Fig. (c) Typical rafter and column [8]

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- **Main framing**

The main framing is made up of the rigid steel frames of the building. The PEB rigid frame contains tapered columns and tapered columns and tapered beam (the fabricated tapered sections are mentioned as built-up members) as stated by [17].

- **Columns**

The main object of the columns is to transfer the vertical load to the foundations. However, a part of the horizontal actions (wind action) is also transferred through the columns as confirmed by [17]. Usually, columns are made by 'I' sections which are constructed to be less costly than other sections. Its depth goes on increasing from the bottom end to the highest end of the column. The column is made of 'I-section' consisting of flanges and web-connected to each other by welding as stated by [18].

- **Rafter**

[19] concluded that the rafter is one of a series of sloped structural members such as wooden beams that expand from the ridge or hip to the wall plate, downslope circumference, or eave, and that are designed to support the roof shingles, roof deck, and its associated loads.

- **Tapered beams**

The tapered beam is one of series of sloped structural members (beams) that ended from the ridge or hip the wall-plate downslope circumference or eave, and that are designed to support the roof deck and connected to loads as confirmed by [17].

SECONDARY MEMBERS

[11] Concluded that the purlins and girts obtain load from roof and wall covering and transfer to the main building frame. Purlins and girts procure lateral bracing to the building columns and rafter and preventing lateral buckling of the compression flanges.

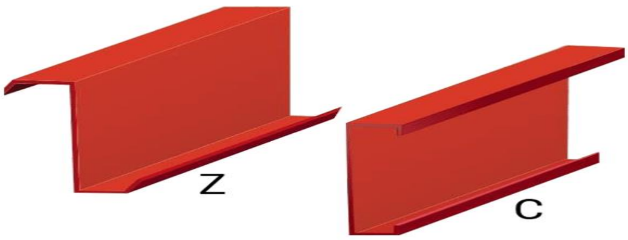

Fig. (d) Typical Purlin Z and C [8]

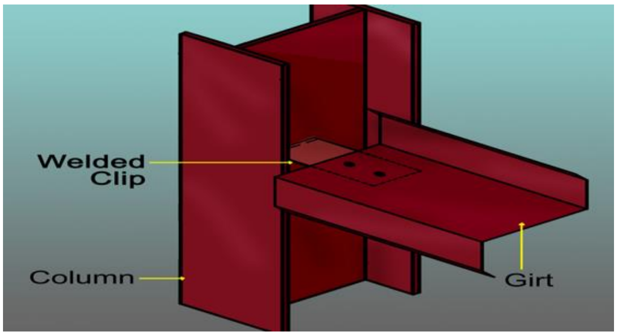

Fig. (e) Typical Girt [8]

Purlin and girt flanges are unequal in width to allow for easier nesting during erection. They shall be pre-punched at the factory to supply field bolting to the rigid frames. They shall be simple or continuous span as required by design as stated by [17].

SHEETING AND CLADDING

The base metal of either galvalume coated steel conforming to ASTM A 792M Grade 345B or aluminum conforming to ASTM B209M as confirmed by [19]. Galvalume coating is 55% Aluminium and about 45% Zinc by weight. An exterior surface coating on painted sheets of 25 microns of epoxy primer with a highly durable polyester finish as stated by [20].

ACCESSORIES

Following are the various accessories of the pre-engineered building which are used in the construction

- **Anchor Bolts**

These are wont to anchor the members to the ground of concrete, concrete foundations, or other supports. These bolts are usually mentioned at the rock bottom of the columns. Bolts are used to anchor the structural member to the concrete floor, foundation, or other support as confirmed by [21]. Anchor bolts are manufactured with circular steel rods having a threading portion at the top for bending and bent up at the bottom for Foundation as stated by [20].

- **Turbo Ventilator**

It is a rotate ventilator of a roof that works on wind energy. If the wind pressure between outside & inside the building is distinct, the air moves through its opening and maintains the equilibrium condition. The main use of using these is that they improve the circulation of air and suffocation is being eliminated as concluded by [21].

- **Louvers**

Louvers frames are standard 26 gauge galvanized steel frames painted with 26 gauge blades. Heavy Duty Louver frames shall be 18 gauges galvanized steel frame cover with 20 gauge blades. Both Standard and Heavy Duty louvers shall be self-framing and self-flashing as confirmed by [19].

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III. TECHNICAL PARAMETERS OF PEB

[8] Concluded that the pre-Engineered Buildings are custom designed to meet purchaser requirements. PEBs are defined for definite measurements. The produced members proper to the designed dimensions. Measurements are taken accurately for the requirements. The basic parameters that can define a PEB are following:-

- **Building Length**

Building lengths are measured from out to outdistance of end wall steel lines as stated by [11]. The length of PEB is the total length extending from one frontend to the buttocks of the building. The length of PEB can be extendable in the future as confirmed by [10].

- **Building width**

The width of the building is the dimension calculated from the outside of the eave strut of one sidewall to the outside of the eave strut of the added sidewall as concluded by [5].

- **Building height**

[11] Concluded that the building height is understood as eave height, is the measurement considered from foot of base plate of major structure column to crest point of the eave strut.

- **Bay Spacing**

The distance between the two adjacent frames of a building is named as a Bay spacing as stated by [10]. The spacing between two frames is called a bay. The distance from the outside of the outer flange of end wall columns and the centerline of the primary interior frame columns are called end Bay length as confirmed by [11]. Interior bay length is that the distance between the middle lines of two adjacent interior mainframes Columns. The economical bay spacing is 7.5m to 8.0m. However, bay length up to 10m is possible as stated by [5].

- **Roof Slope (X/10)**

[5] Concluded that the roof slope is that the angle measured from the inclined roof plane with relating to horizontal face. Any practical roof slope is possible.

- **Roofing and Cladding Materials**

Roofing and cladding materials are used for PEB structure occasion case to their durability, strength, and capability to resist wind pressure, high temperature, weather, etc. as stated by [5].

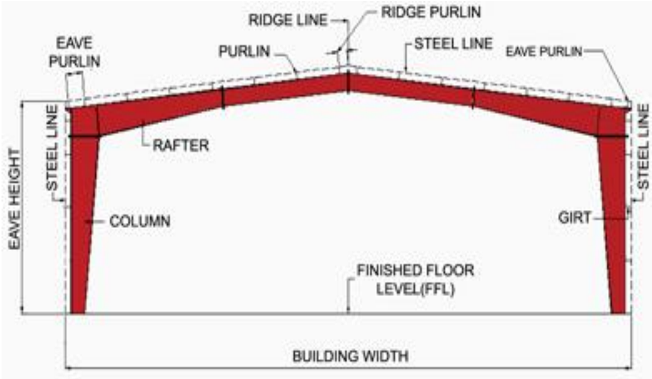

Fig. (f) Typical Pre-Engineered Building Frame [8]

LOAD

The loads acting on the structure include dead load, live load, wind load, collateral load, etc. as confirmed by [7].

- **Dead load**

It includes primary member's self-weight i.e. frames and secondary structural component weight such as purlin, girts, Flange Braces, roof, wall braces, and wallboard as concluded by [16].

- **Live Load**

[10] Concluded that all the movable objects during a building like people, desks, cupboards, and filing cabinets produce an imposed load on the structure. Other sources of live load arise during construction, repair, or maintenance of the building, and these are even more difficult to predict and quantify as confirmed by [7].

- **Wind Load**

The wind has become a really important load in recent years thanks to the extensive use of lighter materials and more efficient building techniques as stated by [10]. Wind loads are governed by wind speed, roof slope, eave height, exposure category, and open wall conditions of the building as confirmed by [22].

- **Collateral Load**

[22] Concluded that the collateral or superimposed dead load is a specific type of dead load that includes the weight of any materials other than the permanent construction. The collateral load is a further weight that generates from additional permanent materials instead of the structural system, for example, ceilings, lighting, mechanical shafts, and mechanical ducting system.

CONCLUSION

- The pre-engineered building is more advantageous than conventional steel building in terms of reduced time and cost-effectiveness, future scope, economy, quality

ISBN: 978-93-90214-19-8

control, fast speed in construction, low maintenance, and simplicity in the erection.

- PEB structure is more conservative than conventional steel structure because of less steel required.
- The Pre-engineered structure is very much in use. PEB technology provides the much-required design flexibility, more cost-effective, and recyclability for steel structure.
- PEB has wide scope in the world. Pre-engineered buildings are one of the foremost preferred choices of construction within the world. Mostly this type of construction is population-free, as well as it is easy to fabricate at any building location.

REFERENCES

[1] A. R. Thorat and S. K. Patil, "A Study of Performance of Pre-Engineered Building of an Industrial Warehouse for Dynamic Load", *Int. Res. J. Eng. Technol.*, vol. 4, no. 6, pp. 2240–2246, 2017.

[2] K. Prabin Kumar, D. Sunny Prakash, "A Study on Design of Industrial Building", *International Journal of Pure and Applied Mathematics*, issue 2018, Volume 119 No. 17, 2791-2795.

[3] M. M. Kumthekar and U. L. Deshpande, "Pre-Engineered Building – A New Trend Of Industrial Building", vol. 3, pp. 10–11, 2018.

[4] Mayuri Patil, "Comparative Study of Analysis & Design of Pre-Engineered Building Using Is 800 : 2007 & Various International Codes", No. 1, pp. 7–18, 2019.

[5] M. S. Reza, S. Afroze, and A. K. Azad, "Modern Installation Process of Pre-Engineered Steel Building", *Int. J. Innov. Eng. Res. Technol.*, vol. 5, no. 1, pp. 22–30, 2018.

[6] S. Kumar, A. P. G. B. Bhaskar, "Study and Analysis of Pre-Engineering Building Structure", pp. 64–66, 2019.

[7] Charkha and Leash S. Sanklecha, "Economizing Steel Building using Pre-engineered Steel Sections", *International Journal of Research in Civil Engineering, Architecture & Design,* Volume 2, Issue 2, April-June, 2014.

[8] Wankhade, S.D, and Pajgade, P. "Review paper on comparison of conventional steel building & pre-engineering steel building", *Int. J. Res. Advent Technology,* 2014, 2, 1–10.

[9] D. D. Katkar and N. . Phadtare, "Review Paper on Comparative Study of an Industrial Pre-Engineered Building with Conventional Steel Building", vol. 5, no. 10, pp. 121–126, 2018.

[10] A. P. Mehendale, P. A. K. Gupta, and P. D. B. Desai, "Overview of Pre-Engineered Buildings", No. 6, 2016.

[11] A. R. Benibagde and P. A. Khedikar, "Review Study on Pre Engineering Building", vol. XII, no. 501, pp. 501–504, 2020.

[12] Mohanraj, V. Preetha, "A Study of Pre-Engineered Building", *International Journal of Trend in Scientific Research and Development (IJTSRD) International,* Volume – 1 Issue – 6 Sep - Oct 2017 ISSN No: 2456 – 6470S.D.

[13] P. S. Lande and V. V Kucheriya, "Comparative Study of an Industrial Pre-Engineered Building with Conventional Steel Building", vol. 2, no. 10, pp. 77–82, 2015.

[14] Vivek Thakre, Mr. Laxmikant Vairagade, "Analysis and Cost Comparative study of Conventional Industrial building with PEB structure", *Journal of Information, Knowledge, and Research in Civil Engineering,* 30/01//2016.ISSN 0975 – 6744, Impact Factor: GIF: 00.9487, SIF: 03.495.

[15] Qazi Syed Shujat, Ravindra Desai, "Comparative Study of an Industrial Warehouse using CSB, PEB and Tabular Sections", *Int. Journal of engineering research and application,* ISSN:2248-9622, Vol. 8, Issue 5 (Part -1)April 2018, pp 53-57.

[16] S. Kalesha, B. S. S. Ratnamala Reddy, and D. C. K. Jagarapu, "An analytical study on pre-engineered buildings using STAAD *pro*", *Mater. Today Proc.*, vol. 33, no. April, pp. 296–302, 2020, DOI: 10.1016/j.matpr.2020.04.076.

[17] Dr. S. Vimala, Vijayalashmi A, Anitha V, "Analysis and design of Pre-engineered building for vehicle parking shed", *International journal of advanced research in engineering and management*, ISSN:2456-2033, pp. 43-65.

[18] Darshan, K.; Sujay, D.; Pavan, "A Comparative Study on the Performance of PEB with CSB considering various parameters", *Int. Res. J. Eng. Technol.* 2017, 4, 1082–1088.

[19] Anisha Goswami and Dr. Tushar Shende, "Pre-Engineered Building Design of an Industrial Warehouse", *International Research Journal of Engineering and Technology (IRJET),* and Volume: 05 Issue: 06 June, P-ISSN: 2395-0072.

[20] KokaniSharad, KhichiPrashant, Pardeshi Dig Vijay Singh, RautNitin, Prof. Gawali N.B, "Design & Analysis of Pre-Engineered Building Structure", *International Journal for Scientific Research & Development,* Issue 02, 2018, Vol. 6.

[21] Shrunkala V Bhagatkar, Farman Iqbal Shaikh, Bhanu Prakash Gupta, and Deepak Kharta, *"International journal of engineering research and applications,* ISSN: 2248, Vol.5, Issue3, March 2015, pp.05-09.

[22] M. U. Saleem and H. J. Qureshi, "Design solutions for the sustainable construction of pre-engineered steel buildings", *Sustain.*, vol. 10, no. 6, 2018, DOI: 10.3390/su10061761.

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ISBN: 978-93-90214-19-8

Review on the Development of Constructed Wetlands at National and International Levels

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Abstract - Treatment of wastewater by adopting natural treatment systems to meet the need of existing water requirement is one of the current techniques used by most of the contemporary countries of the world. Constructed Wetland is a natural, profitable, easy in operation and maintenance, energy-efficient and eco-friendly wastewater treatment technology used to produce treated water with quality and bioenergy. This water caters the needs like irrigation sector, safe recharge of groundwater quantity and disposal into surface water bodies as well as municipal reuse, substantiating the expensive, power consuming and complex conventional treatment technologies. Earlier SCI publications by various scientists from past two and a half decades are reviewed in the present study, on International and National scale to identify major contributions in this developing approach and categorize Constructed Wetlands (CWs), to assess their performance in the pollutant removal from different types of wastewater. Most of the CWswere successful in the removal of organic matter, nutrients, suspended solids and faecal coliforms to the maximum extent and were working at decentralized levels in most of the municipalities of developed countries. In India, excellent results were observed about the removal of heavy metals and pH apart from above-mentioned pollutants, but the application of this technology in the society is limited. CW integrated with other treatment systems like Bio-electrochemical system or combining primary treatment and Algal ponds with CWs was found to improve the performance on the whole, apart from combining two types of CWs in the treatment. Future work can be extended to study the removal of hazardous pollutants like heavy metals, pathogenic micro-organisms and other dissolved impurities in wastewater, treatment of sludge absorbed in the soil medium and create public awareness which helps in implementing this technology in the society.

Keywords: Constructed wetlands, removal efficiency, pollutants, bioenergy, quality

Highlights :

- ***Role of phytoremediation in wastewater treatment***
- ***Categorizing different types of Constructed wetlands***
- ***International and National level contributions***
- ***Qualitative analyses on removal efficiency of pollutants***
- ***Societal application of technology***

Introduction

Constructed wetland is an engineered mechanism that uses natural components like vegetation, soil, and organisms to treat domestic, industrial and municipal wastewater. Similar to natural wetland constructed wetland also acts as a bio-filter and can remove a range of pollutants such as organic matter, nutrients, pathogens and heavy metals from the water. They are the need of the hour to meet the scarcity of water on earth. Conventional methods of wastewater treatment pose financial problems and ecological hazards leading to difficulty in the management of the environment on the whole. The present work is based on a comparative study of development in using constructed wetlands for treating wastewater in India against other countries of the world. For this, a critical review on the removal of BOD, COD, Nitrogen, Phosphorous and pathogenic bacteria from wastewater is assessed from past two decade papers contributed from various disciplines by different scientists and analyse the development in this sector to the possible extent.CWs are classified into various types,based on hydrology (surface flow (SF), subsurface flow(SSF)),based on macrophytes (submerged aquatic beds(SAB), floating leaved aquatic(FLA))[Kadlec,1995] and flow path(horizontal(HF) and vertical(VF))[Vymazal,2011].World'sfirst constructed wetland was started in 1904 in Australia [Patil,2017]. First experiment using wetlands with macrophytes for wastewater treatment was carried out in Germany in 1950s [Padma Vasudevan,2011]. Two marked German researchers laid the foundation for CWs, Dr.Kathea Siedel in 1960s and Dr.Reinhold Kickuth in 1970s[Kickuth, R.,1998]. Over the past six decades, the evolution in the functioning of CWs has been observed to play an important role in safeguarding the quality of the environment, by adopting these cost-effective techniques in resolving many ecological adversities caused by anthropogenic activities like acid mine drainage [Mitsch and Wise,1998], domestic wastewater treatment [Konnerup et al.,2009], industrial effluents [Ji et al.,2007], agricultural runoff [Fink and Mitsch,2004].

A chronological review of the contributions of scientists towards the removal of pollutants from wastewater shows that 90% of removal efficiency of parameters like BOD, COD, TSS and pathogens can be achieved using SF CWs [Verhoeven,1999] in the Netherlands and ina similar manner using SSF constructed wetlands apart from the above parameters almost 90% reduction in faecal coliform was observed [Neralla,2000]. A horizontal SSF constructed wetland based on simple thumb rules and regression equations, followed by Monod-type equations and ending with the complex dynamic compartmental model in designing shows that the state-of-the-art k-C* model implies to be the most applicable design tool if the designer makes sure that is the assumptions are fulfilled and is aware of the drawbacks in the model [Rousseau et al.,2004]. A combined approach of a VF CW with trickling filter is observed to drop the pollutant level to third/fourth order concerning BOD, COD and faecal coliforms in magnitude from their initial concentration after 8 hours in the recycling of greywater for irrigation in small communities [Gross et al.,2007]. Another similar approach on using two pilot vertical flow CWs for treating municipal wastewater for irrigation reuse making use of Typha latifolia plants in the first and Phragmites australis plants in the other wetland resulted in high removal efficiency of BOD, COD, Nitrogen and Potassium [Morari,2009]. As a part of a project under MEDA funded regional zero-m project 4 technological demonstration centres at Egypt, Turkey, Morocco and Tunisia, consisting of several multistage vertical and horizontal CWs were implemented and observed that removal efficiency of various parameters is found to give satisfactory results [F. Masi et al.,2010].

A detailed study of the review of development in the field of CWs from 1991 to 2011 using the scientometric approach to quantitatively assess worldwide scientific research and statistically assess latest trends and way forward in Science Citation Index-Expanded database for the period mentioned, it is observed that important constructed wetland research hotspots namely water, nutrients, plants and flow and soil are the dominant areas previously and probably may become a primary research process in years ahead as well [Wei Zhi, Guodong Ji,2012]. A comprehensive review on the removal of organics and Nitrogen from effluent identifies significant environmental parameters such as pH, DO, and temperature, functional factors like organic carbon availability, loading, feeding mode, retention time, recirculation, harvesting play an important role in improving the removal efficiency of pollutants in SSF CWs[TanveerSaeed, Guangzhi Sun, 2012]. A study on the removal of heavy metals, Cd(II), Hg(II), Cr(VI) and Pb(II) in Gynericum sagittatum, Colocasia esculenta and Heliconia psittacorum planted in a constructed wetland treating synthetic landfill leachate revealed that removal efficiency of 66% of COD, 67% of TKN and 72% of NH_4 – N and heavy metal removal ranged between 92 to 98% of influent [C.A.Madera-Parra et al.,2015]. A closer study on six years of performance data for a vertical flow constructed wetland for treating winery process water and domestic sewage at a winery in the Niagara region of Ontario has shown that treatment efficiencies were 99% for COD, 99% for carbonaceous COD, 98% for TSS, 83% for Total Phosphorous, 94% for TKN and 85% of Ammonium [Eric R. Rozema et al.,2016]. A review of the experimental study on comparison of purification capacity of domestic wastewater using two species of plants, Phragmites australis and Cyperuspapyrus in vertical SSF constructed wetlands, indicated that the latter species presented a greater removal capacity of BOD(81%), COD(70%), Ammonical Nitrogen(69%), Total Phosphorous(50%), total coliform(98%), faecal coliforms(96%), whereas the former retains more solids [Garcia-Avila et al.,2019]. A review on the life cycle assessment(LCA) of nutrient recycling from wastewater especially N and P, suggested positive environmental outcomes minimizing chemical inputs and source separation of human excreta is achieved and it also shows a need to improve consistency in methods adopted, guarantee lucidity of inventory and methods, considerable unpredictability in relative LCA context, combine latest cross-disciplinary knowledge into LCA models and consider decentralized impacts of recycled nutrient products [Lam et al.,2020].

India's first primary constructed wetland was installed at Sainik school at Bhubaneswar and a considerable removal of pollutants was observed [Juwarkar,1995]. A review of a work in New Delhi at the banks of Yamuna river showed that treatment of urban runoff water can be carried out using CWs by proposing a methodology to transfer the drain water through aqueducts to the opposite bank, where there is the availability of unused flood plains of the river, to save the land for other uses and for reducing pollution as well as create a healthy ecosystem near the river banks [Atul K. Mittal et al.,2006]. A study was conducted to investigate the Chromium and Nickel removal for an aqueous solution using constructed wetland with Canna indica species with a removal efficiency 98.3% and 96.2% of Cr and Ni respectively was observed [Asheesh Kumar Yadav et al., 2010]. A scholarly review on CWs for the urban stormwater management was carried to show the potentiality of these wetlands for treating stormwater by looking at the current research initiatives towards execution of this technology in the future [Piyush Malavyia and Ashish Singh,2012]. A report based on evaluation of textile wastewater treatment for the village of Jasol, Rajasthan, proposed beginning with pre-treatment and primary treatment followed by SSF CWs for the secondary processing and finally with an industrial scale solar stills to remove salts from water [Beau Garrett et al., 2016].

Analytical Review

Metadata required for this review is derived from experimental observation on various types of CWs carried by scientists all over the world with a critical search for the removal of pH, BOD, COD, TSS, TN, TP, TKN, Faecal Coliforms, Heavy Metals and Sulphate. In this study, the related articles were searched from the database available in Google search, Scopus and Web of Science. Globally, 140 research publications from the past 25 years were comprehensively investigated. Some of the significant analytical results starting from 1994 to 2020 at the international level were tabulated in Table 1, in which 20 countries selected based on the development in this field during this period. Similarly, 20 major Indian scientific and technical contributions towards the treatment of wastewater using CWs and their removal efficiency of pollutants were tabulated in Table 2. Most of them are constructed according to regulations were given by either USEPA(1993) or CPCB [Print_Version_of CW Manual.2019] of India and some of them are laboratory-scale experiments. Different types of CWs SSF, SF, HF and VF were adopted based on the requirement. In some cases laboratory set up and hybrid(HYB), CWs were also chosen to achieve maximum efficiency.

Components of CWs - include media, made up of gravel or aggregates of different sizes, river sand and clay enclosed in a masonry structure of specific required dimensions(CPCB/USEPA) with bottom impermeable liners of PVC or LDPE or HDPE and covered with a Geotextile to prevent the liner from damage caused by sharp-edged filtration material.

Variables involved -

Aspect Ratio,[$A_c = Q_s$ / [K_f(dH/dS)],

where A_c is length to width ratio, Q_s is average flow in m/s, K_f is hydraulic conductivity in m/s and dH/ds is slope in m m^{-1}[J.Vymazal, 2002],

Surface Area, [$A_h = Q_d(\ln C_o - \ln C)/K_{BOD}$],

where Q_d is average flow rate, C_o is influent BOD in mg/l and C is effluent BOD in mg/l, K_{BOD} is Rate constant in m/day[J.Vymazal, 2002],

Hydraulic Retention Time, HRT = hlw/q where h is effective depth, l and ware length and width of the CW respectively and q is average flow rate in m^3/day,[Kyambaddeet al.,2005].

Treatment efficiency for the removal of various Heavy metals was determined by retention equation,

R = 1 – (C_e/C_i) X 100, where R, $C_e$andC_i are removal efficiency, effluent and influent concentrations of various Heavy metals respectively.

Root Concentration Factor(RCF) = $C_{root}/C_{wastewater}$

Aerial tissue Concentration Factor(ACF) = $C_{aerial\ parts}/C_{wastewater}$

where $_{the\ root}$, $C_{wastewater}$and$C_{aerial\ parts}$ represent heavy metal concentration in the root, wastewater and aerial parts respectively[Khan et al.,2009].

S.No	Scientist with location	Type of wetland	Type of wastewater	BOD %	COD %	TSS %	TN %	TP %	TKN %	Faecal coliforms %	Heavy Metals %
1.	Tanner 1994 Newzealand	Horizontal and up flow	Dairy farm	90	-	90	90	80	-	-	-
2.	Greenway 1999 Queensland	SSF	Domestic	89	-	77	86	65	-	-	-
3.	Verhoeven 1999 Netherlands	SF	Domestic	95	81	-	35	26		99	-
4.	Neralla 2000 Texas	SSF	Domestic	90	-	88	-	-	-	99	-
5.	Scultz 2001 South Africa	SF	Agricultural water	-	-	78	84	75	-	-	-
6.	Vymazal 2002 Czech Republic	SSF	Domestic	88	-	84	42	51	-	-	-
7	Peter D Jenssen 2003 Norway	HSSF	Greywater	82	-	-	50	78	-	-	-
8	A.Weibner 2005 Germany	Laboratory scale	Sewage	# 93	-	-	82*	-	-	-	-
9	Kyambadde 2005 Uganda	VSF	Municipal sewage	86	-	-	74	70	-	-	-
10	Sirianuntapiboon 2007 Thailand	SSF	Sewage	91	-	91	86	87	-	-	-
11	Ji 2007 China	SF	Industrial	88	80	-	-	-	86	-	-

ISBN: 978-93-90214-19-8

12	Caselles 2007 Spain	HSSF	Urban	-	-	-	90	-	-	-	-
13	Khan 2009 Pakistan	SF	Industrial	-	-	-	-	-	-	-	Pb(50)Cd(91),Fe(74),Ni(40),Cr(89),Cu(48)
14	Galletti 2010 Italy	HF	Grey-water	-	-	-	-	-	-	-	Cu(34),Ni(2) Zn(6)
15	Ana Galvio 2012 Lisbon	HF	Synthetic wastewater	-	84	-	-	-	-	-	-
16	Pandey 2013 Nepal	VSSF	Municipal	-	67	73	76	70	30	75	-
17	Madera-Parra 2014 Colombia	Lab-scale	Synthetic landfill leachate	-	66	-	72*		67		Pb,Cd,Hg (98)
18	Rozema 2016 Canada	VF	Winery	-	99	98	85*	83	94	-	-
19	C Ramprasad 2018 India	Hybrid	Greywater	97	98	99	99	93	-	99	-
20	Fernando Garcia 2019 Ecuador	VSSF	Municipal	81	79	-	70	50	-	96	-

(#TOC) (*NH_3-N)

Table 1 Review on Pollutant Removal Efficiency from wastewater at International Level

Biological Concentration Factor(BCF,L/kg) $=C_p/C_w$, where C_p -Metal concentration in the plant tissue mg/kg-DryWeight(DW), C_w - Metal concentration in water mg/L. A higher value of BCF indicates a better phytoaccumulation capability.

Translocation Factor(TF) = C_A/C_U , C_A - Metal concentration in above ground tissues mg/kg-DW, C_U - Metal concentration in underground tissues mg/kg-DW[Madera-Parra et al.,2015].

Plant species in general used in CWs were –

Axonopus compressus(carpet grass), Phragmites australis, Typha latifolia, T. angustata, Eichornia cressipes, Juncus effucus, J.kraussi, Schoenoplectus validus, Canna indica, Scirpus littoralis, Colocasia esculenta, Sagittaria lancifolia, Gladiolus sp., Submerged sp. – Ceratophyllum demersum, Free-floating – Duckweed, Water lily, Aquatic weeds – Ipomea sp., Water ferns– Ceratopteris, Marselia, Emergent sp. – Cyperus involucratus, Sedges – Phragmitis karka.

One of the important phenomena in CWs is *Evapotranspiration* which results in loss of water content. This is estimated as Potential evapotranspiration(PET) in mm/month by Thornthwaite equation as,

$PET = 16(L/12)*(N/30)*(10T_d/I)^{\alpha}$,

where T_d is the average daily temperature in degree Celsius, (use 0 if temperature is negative) of the month concerned, N is the number of days in the month, L is the average daily length (hours) of the month being calculated, $\alpha = (6.75*10^{-7})I^3 - (7.71*10^{-5})I^2 + (1.792*10^{-2})I + 0.49239$,

$I = {}^{12}\sum_{i=1} (T_{mi}/5)^{1.514}$ is a heat index which depends on the 12 monthly mean temperature T_{mi}.

Methods followed for analyses of water quality were basically according to APHA(Americal Public Health Association 1989 Washington D.C.)/APHA-AWWA-WPCF(1995). Heavy metals were analysed by AAS, Inductively Coupled Plasma Mass Spectrometer, EutechCyberscan PCD 650 multiparameter kit and Toxicity Characteristic Leaching Procedure(TCLP) test is carried to study leachability of metals which should be negligible for safe disposal.

Statistical Analysis is done using various software like MINITAB release 13.31 for Windows, ANOVA, SPSS 14.0 by SPSS Inc., SYSTAC Statistical Software package, SPSS 11.5/19.0(SPSS USA), BCR-RM 060 Lagarosiphon major and BCR – RM 279 Ulva Lactuca(European Commission, Community Bureau of Reference, Brussels, Belgium), ICP – MS Technique, R Programming Language Software(Version2.13-2012), Shapiro Wilk test for normality, Bartlett tests for homogeneity, IBM SPSS 20, Tukey's Multiple Comparison Test, Landsat MSS, GRASS GIS, Duncan's Multiple Range Test(DMRT).

k – C model in the design of CWs is an important mathematical method of quantifying the effect of design variables via Regression model given by Kadlec (1996), used in the treatment of wastewater adopting CWs, the optimal values of k, the aerial rate constant in m/yr and C^*, irreducible background concentration of various parameters using EXCEL are obtained. From these values, using q, Hydraulic Loading Rate (HLR), temperature, to modify k values, the concentration for different parameters can be predicted. The model explains the k – C^* relationship by the following mathematical equations to be used in an experimental study[K.V.Jaykumar and M.N.Dandagi,2004].

$C_{outlet} = C^* + (C_{inlet} - C^*)^* Exp(-kt)$ (1)

where t is detention time, and

$C_{predicted} = C^* + (C_{inlet} - C^*)^* Exp(-kq)$ (2)

where q = Q/A, HLR in m/yr

Wastewater from various sectors of society was used in the treatment including greywater, municipal sewage, domestic wastewater, urban runoff, agricultural runoff, industrial effluents like dairy farms, oil refineries, acid mine drainage, winery and landfill leachate.

Review of removal efficiency of pollutants at the international level

Phytoremediation is one of the treatment techniques of wastewater which can be dated back to the year 1900 in the world. CWs concept involves the application of multi-disciplinary expertise to simulate the natural conditions of wetlands artificially to remove pollutants from wastewater which may be harmful in higher concentration as well hazardous chemicals like heavy metals apart from Nitrogen, Phosphorous, organic matter and pathological bacteria. Environmental factors like pH, DO, temperature, functional factors - organic carbon availability, loading rate, feed mode, retention time, recirculation and harvesting play an intricate role in the nitrogen and organic removal pathways [T. Saeed and G.Sun,2012]. Four dominant factors - water, nutrients, plants and flow were found to play a significant role apart from the soil in the CWs research development reported from a review from 1991 to 2011 using SCI-Expanded database [W.Zhi and G.Ji,2012]. Most of the present work from 2010 onwards was found to be concentrated on phytoremediation for reducing BOD, COD and nutrients from wastewater and the future work can be extended to removal of heavy metals and pathogens, making treated water suitable for reuse in society.

Analysis of removal efficiency of pollutants at the national level

Removal efficiency(%) of various pollutants like pH, BOD, COD, TSS, TKN, TN, TP, Faecal coliform, Heavy metals and Sulphate are studied for contribution from different parts of the country. The removal efficiency of pollutants by adopting the CW treatment technique is found to give satisfactory results, but in most cases, the technique is at the research level only, but not at the application level.

S.No	Scientist with location	Type of wetland	Type of wastewater	pH	BOD	COD	TSS	TN	TP	TKN	Faecal coliforms	Heavy Metals	SO_4^{--}
1.	Juwarkar 1995 Bhubaneswar	VF	Domestic	-	75	-	-	50	85	-	-	-	-
2	Jaykumar 2003 Warangal	SF	Municipal	-	87	71	90	-	76	89	-	-	70
3	S.Bala Prasad 2010 Kolleru	Lab Setup	Agricultural & Industrial	4.8-7.4	61	81	-	-	-	-	-	-	-
4	DeblinaGhosh 2010 Delhi	SSF	Sewage	-	94	97	-	90	92	100	-	-	-
5	SukantaRana 2011 Kalyani	SF	Sewage	-	-	-	-	-	-	-	-	Cd(33)	-
6	Prashant 2013 Ujjain	SSF	Domestic	-	75	-	82	78	-	78	-	-	-
7	Sowyma 2014 Vellore	Lab Set up	Septic Effluent	_	70	40	62	-	-	-	-	Pb(95),Cr(94), Fe(94)	-
8	Ahamad 2014 Kashmir	NWL	Runoff	-	-	-	-	-	-	-	-	Zn(98),Mo(81),Ba(78),Al(77)	-
9	ArunBabu 2015 Kottayam	SSF	Grey-water	-	-	95	93	** 98	*** 67	-	-	-	-
10	S.A.Tondon 2015 Mumbai	VSSF	Municipal	-	12	-	-	** 44	42	-	-	-	-
11	Kumar 2015 Karnal	SF	Sewage	-	-	-	-	76	61	-	99	-	-
12	Gargi Sharma 2016 Jaipur	VF	Sewage	-	-	55	-	*51	-	40	-	-	-
13	Upadhyay 2017 Lucknow	HF	Sewage	-	88	-	72	67	*** 74	-	-	Zn(40),Cu(39), Pb(38),Cr(20)	-
14	TV Ramachandra 2018 Bengaluru	Hybrid	Greywater	-	90	77	-	** 33	*** 75	-	-	-	-

ISBN: 978-93-90214-19-8

15	Verma 2018 Dehradun	HF	Dairy Water	-	73	72	73	** 63	49	-	-	Cr(47),Fe(65) Ni(65)	47
		VF		-	83	82	55	** 48	60	-	-	Cr(47),Fe(65), Ni(65)	60
16	Jethwa 2018 Raipur	Lab set up	Wastewater	-	-	-	-	-	82	-	-	-	-
17	VivekRana 2018 Dhanbad	Lab set up	Municipal	-	-	71	-	-	-	72	-	Cu(83),Cd(83),Mn(74),Cr(74), Co(84),Zn(66), Pb(78),Ni(80)	-
18	Ramcharan, Srikanth 2020 Goa	VF	Domestic	-	69	-	-	* 77	64	76	-	-	
19	Swetha S, Chakraborty S 2020 Guwahati	HSSF	Acid mine drainage	From 2.1 to 6.4	-	-	-	-	-	-	-	Cr(99),Ni(97), Co(95),Fe(91), Al(59)	-
20	M.Kumar, R.Singh 2020 Gandhinagar	Hybrid	Municipal Wastewater	-	-	-	-	96, ** 83	91	-	-	-	84

(*NH_3-N,** NO_3^-) (*** PO_4^{3-})

Table 2 Review on Pollutant Removal Efficiency from wastewater at National Level

Results and Discussions

Removal Efficiencies at International scale

Overall 20 countries are reviewed from past two and a half decades to identify the potential pollutant removal capacity of CWs. The locations of the countries along with the pollutants considered by the scientists in the study are depicted in the following Figure 1.

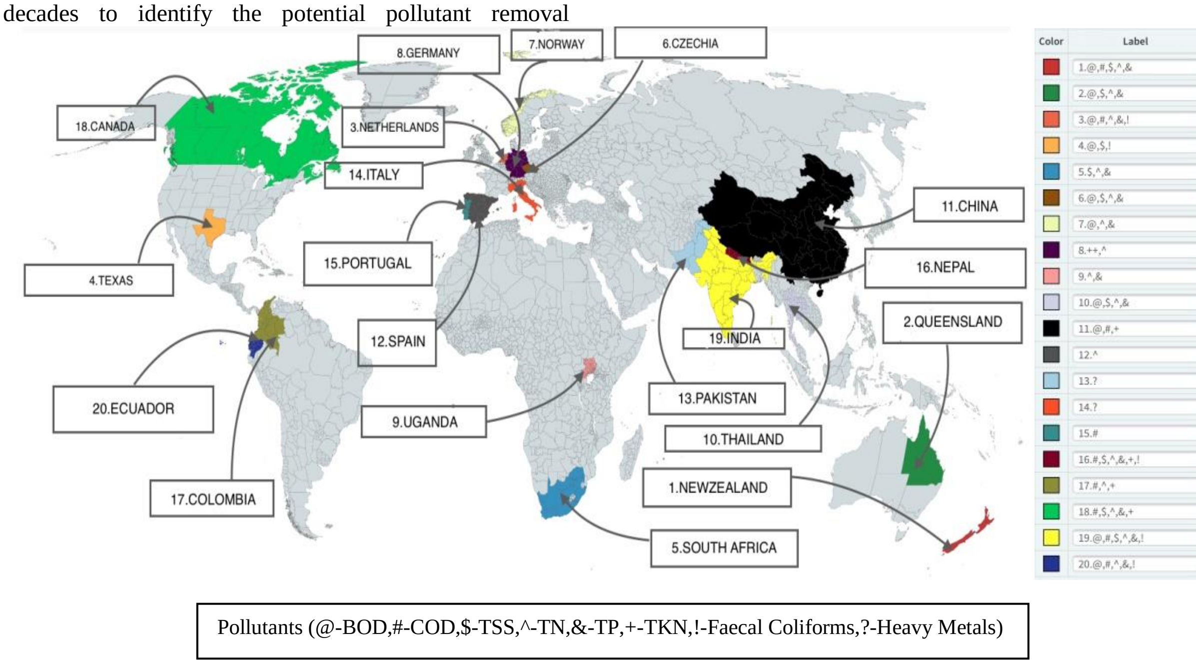


Figure 1 World Map showing Countries considered for review of Removal Efficiency of Pollutants at International Level

The following Graphs (1 and 2) were plotted to pictorially depict the trends in removal efficiency of pollutants from wastewater using the data described in Table 1 for 20 countries all over the world and for convenient understanding this data is plotted in two different graphs taking the study from 10 countries at a time.

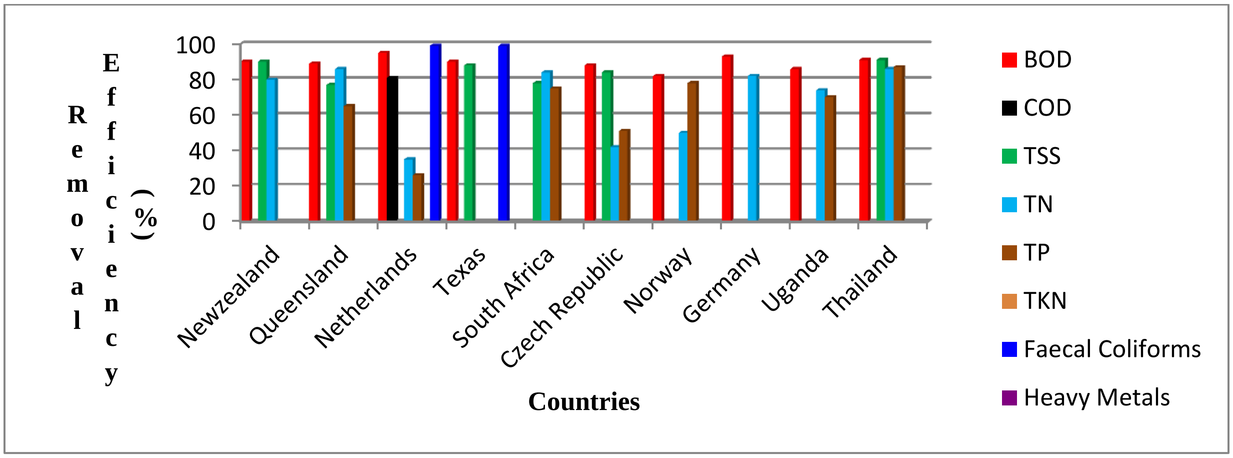


Figure 2: Graph 1 showing a plot between countries considered against Pollutant removal efficiency (%)

The results of these observations based on the classification like SF, SSF, VF, HF etc. and factors responsible for variations in performance were discussed below in detail.

Horizontal Flow CWs

Pollutant reduction rate per unit treatment volume showed a positive correlation with mass loading rate and vegetation used is Schoenoplectusvalidus in four units of HF CWs treating dairy wastewater with 90% removal of BOD, TSS, TN and 80% TP removal and up flow of wastewater showing reduced levels of TN and TP removal when loading rates were increased [Tanner et al.,1994]. In an assessment of nutrient removal by substrate-free HF CWs with Cyperus papyrus and Miscanthidium violaceum has showed removal rate of BOD(86%), TN(74%) and TP(70%) with higher biomass and nutrient uptake by C. papyrus than M.violaceum[Kyambadde et al.,2005]. The response of short-term sudden organic load rise in influent COD on nine HF CWs habituated with Phragmites australis and Scirpus has showed a decrease in removal efficiencies in treating synthetic wastewater and the biofilm disturbance created by the presence of invasive millipedes on removal efficiency, which improved when the mass load was lowered, ultimately removing 84% of COD [15. Ana Galvao and J.Matos,2012].

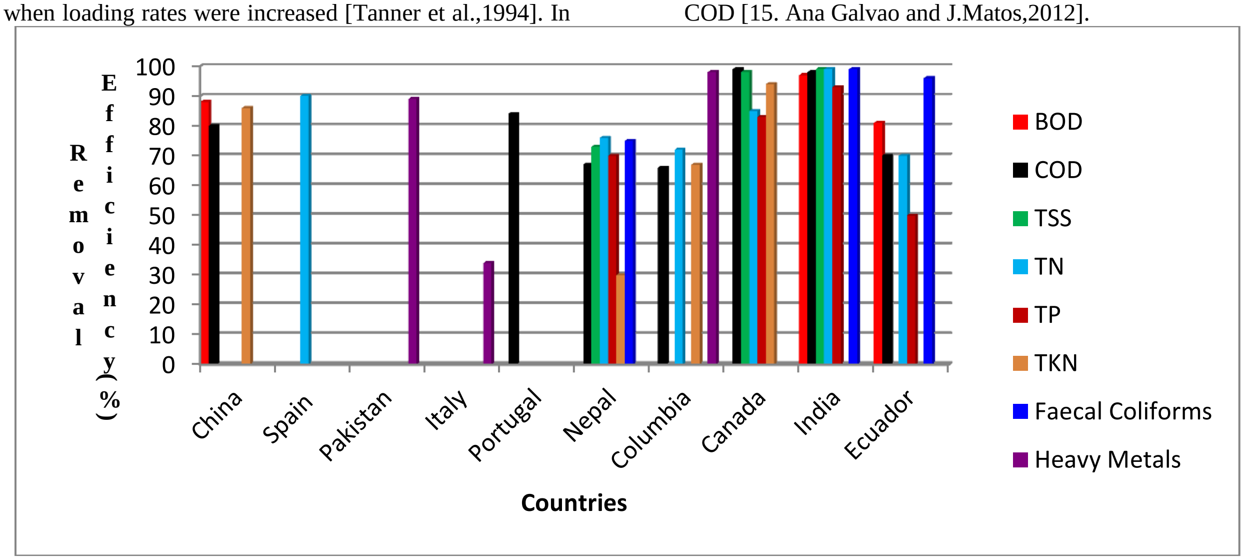


Figure 3: Graph 2 showing a plot between remaining countries considered against Pollutant removal efficiency(%)

Vertical Flow CWs

ISBN: 978-93-90214-19-8

A six years performance observation of VF CWs for the treatment of winery wastewater at Canada in humid climate using Typha latifolia and Schoenoplectustabernaemontani as plants in the bed has removed 99% of COD, 98 % of TSS, 83% of TP, 94% of TKN and 85% of NH_4 – N in which wood chips were used to facilitate denitrification process [Rozema et al.,2016].

Sub-Surface Flow CWs

Ornamental plants like Cannaflaccida(Canna lily), Colocasiaesculenta(elephant ears), Gladiolus sp., Sagittarialancifolia(arrowheads) were used in SSF CWs in eight locations of Texas to purify residential sewage resulted in the removal of BOD(90%), TSS(88%), Faecal coliforms(99%) [Neralla et al.,2000]. A study on the effect of plantation pattern of SSF CW with mono and mixed cultures of Typha latifolia and Canna siamensis to treat sewage has shown that both types of beds with monocultures did not show much difference in pollutant removal efficiency, but a mixed culture of both has shown highest efficiency of BOD(91%), TSS(91%), NH_4-N(86), TP(87%)[Sirianuntapaboon,2007].

Surface Flow CWs

A contribution from the Netherlands showed the use of SF CW and infiltration wetlands in purifying residential sewage efficiently for removing pollutants using Phragmites, Typha or Scirpus species in them in the order of Faecal coliform(99%), BOD(95%), COD(81%) and TN and TP to a lesser extent as 35% and 26% respectively [J.Verhoeven and A.Meuleman,1999]. The effectiveness of an SF CW with Typha capensis, Juncuskraussi and Cyperus dives on retention of pesticide pollution from the non-point source was found to be an interesting study showing the presence of pesticides introduced at the inlet was undetectable at the outlet indicating the retention capacity of a wetland to these and a toxicological analysis using a Chironomus bioassay insitu at the wetland inlet and outlet revealed an 89% reduction in toxicity, apart from the reduction in TSS(78%), TN(84%) and TP(75%) [Ralf Schulz and S.Peall,2001]. Water polluted with heavy oil treated by SF CW with reed beds 1,2 in three years experimental study showed that mean removal efficiencies of red bed 1 was COD(80%), BOD(88%), TKN(86%) and Oil(93%) and reed bed 2 was COD(71%), BOD(77%), TKN(81%) and Oil(92%) throwing light on the capacity of CWs in the removal of oil [Ji et al.,2007]. Industrial wastewater treatment was carried out using SF CW with native plant species of Pakistan like Typha latifolia, Phragmites australis, Ceratophyllumdemersum, Juncusarticulatus etc. which has shown removal efficiency of heavy metals in the order of Cd(92%)>Cr(89%)>Fe(74%)>Pb(50%)>Cu(48%)>Ni(41 %) [Khan et al.,2009]. A pilot study of eight free water SF CWs and one SSF located in three geographical regions with tropical, sub-tropical and arid climates in Queensland to treat municipal wastewater has shown that the removal efficiency of pollutants as BOD(89%), TSS(77%), TN(86%) and TP(<13%) in free water surface system, whereas in single household SSF system TP was reduced to 65% and Emergent species were found to accumulate nutrient content than submerged or free-floating species of plants [M. Greenway and A.Woolley,1999].

Horizontal Subsurface Flow CWs

A similar ten-year study of wetland systems in the Czech Republic has shown a majority of 100 were adopting HSSF type with Phragmites australis as dominant species to treat domestic wastewater, revealed that organic compounds were degraded both aerobically and anaerobically with a pollutant removal efficiency of BOD(88%), TSS(84%), TN(42%), TP(51), COD(75%) [J. Vymazal,2002]. A review on the study of the effect of physicochemical pre-treatment on the treatment of urban wastewater using HSSF CWs with Phragmites australis conducted on the experimental scale has not shown much difference between the two units with and without pre-treatment of wastewater concerning removal efficiency of pollutants except that slightly higher results for COD were observed for HSSF fed with pretreated wastewater and 20% reduction in conductivity was observed in CW fed with settled wastewater and Ammonia stripping was 90% [Aracelly Caselles-Osario,2007]. Distribution of accumulation of heavy metals in plant parts above and below ground was compared by using HSSF CW to treat greywater with Phragmites australis and found that % distribution of metals below and above ground were 57% and 43% for Cu respectively, that for Ni was 43% and 57% respectively and for Zn was 34% and 66% respectively. The removal efficiency of Cu above ground tissue was 34% [AlessioGalletti and J.Garcia,2010]. A combined approach of an aerobic biofilter with HSSF CW in the cold climate of Norway to treat greywater has resulted in a successful reduction in organic matter, indicator bacteria, nitrogen and phosphorous content from wastewater with a compact design suitable for urban use with the effluent water suitable for irrigation or groundwater recharge etc. with monitored removal efficiencies of BOD(82%), TN(50%), TP(78%) [Peter.D.Jenssen and Vrale L,2003].

Vertical Subsurface Flow CWs

Two units of VSSF CWs vegetated using Cyperus papyrus and Phragmites australis are compared in the treatment municipal wastewater have shown that C.papyrus was more efficient as compared to P.australis because roots of former contributed towards the microbial site fixation, ample retention period of sewage, trapping and sedimenting suspended solids, the surface area for adsorption of contaminants, absorption in plant tissues resulting in removal efficiencies as BOD(81%), COD(70%), NH_4-N(70%), TP(50%), Total coliforms(99%), Faecal coliforms(96%) [Fernando Garcia-Avila et al.,2019]. In a comparison between VSSF and HSSF planted and unplanted CWs it is observed that VSSF planted bed is more efficient in the removal of pollutants because VF beds are in a moderately oxidized state whereas HF beds are in a reduced state and the removal efficiencies are COD(67%), TSS(73%), TN(76%), TP(70%), TKN(30%), Faecal coliforms(75%) [M.K.Pandey et al.,2013].

LabscaleCWs

A lab reactor planted with Juncus effuses was used in the treatment of synthetic wastewater to study the affect of redox condition dynamics on removal efficiency of C and N by CW has shown daily variations in redox from -200mV to +200mV and steady-state conditions were achieved throughout the period showing high removal efficiency of TOC(93%), NH_3(82%), NO_3^-(98%) and in summer increase in efficiency was also noted [A. Weibner et al.,2005]. A lab-scale assessment study on accumulation of heavy metals in Gynerium sagittatum(Gs), Colocasia esculenta(Ce), Heliconia psittacorum(He) used in CW treating synthetic landfill leachate was studied to monitor metal concentration in influent, effluent, root, stem branches and leaves of plants and overall pollutant removal of COD, TKN and NH_4^+-N were – 66, 67 and 72% respectively and heavy metal removal ranged between 92 to 98% with roots showing higher metal content than shoots [C.A.Madera-Parra et al.,2015].

HybridCWs

Three pilot-scale SSF CWs, HF, VF and baffle type Hybrid(HY) were used in the treatment of greywater, which was continuously fed with wastewater with Phragmites australis as vegetation has shown maximum efficiency in removal of pollutants in HYCW was in the order of BOD, COD, TSS, TP, TN and Faecal coliforms, 96, 97, 99, 93, 99, 99% respectively. The removal order of Heavy metals was Cu(96.4)>Cr(92.9)>Pb(91.7)>Ni(89.3)>As(76.4)>Zn(75.8)>Cd(71.9)% and the three wetlands performed well in summer [C.Ramprasad and L.Philip,2018].

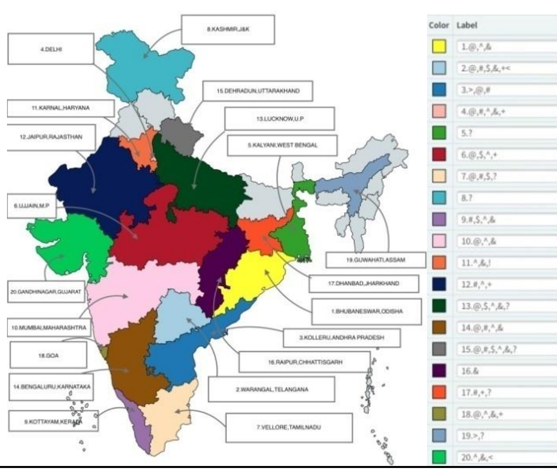
Summary of review at International level

SF CWs were studied more as compared to other types, followed by HSSF CWsgiving optimum pollutant removal efficiency. Maximum efficiency achieved for BOD removal was 97% adopting HYB CW(VF and HF) followed by 95% by adopting SSF CW. In a similar manner COD removal was maximum of 99% using VF CW followed by 98% using HYB CW and TSS also the same type of CW have shown 98% and 99% respectively.

HYB CW performance was shown to give maximum efficiency of most of the pollutants and can be stated as the most preferable type of CWs. Faecal coliforms were found to be removed to a satisfactory extent by using SF/SSF/VSSF/HYB CW of greater than 95% from wastewater.

Removal Efficiencies at National level

Similar to international review on CWs 20 cities from different states are selected to study the level of development and application of CWs in wastewater treatment from past two and a half decades in India. The locations of these places were marked in India map with different colours and symbols denoting different pollutants in wastewater studied are depicted in the following Figure 4.



Pollutants (>-pH, @-BOD,#-COD,$-TSS,^-TN,&-TP,+-TKN,!-Faecal Coliforms,?-Heavy Metals,<-SO_4^{--})

Figure 4: State with the city considered for review of Removal Efficiency of Pollutants at the national level

The following Graphs (3 and 4) were plotted to pictorially depict the trends in removal efficiency of pollutants from wastewater using the data described in Table 2 for 20 locations covering 20 states all over India and for convenient understanding this data is plotted in two different graphs taking the study from 10 locations at a time.

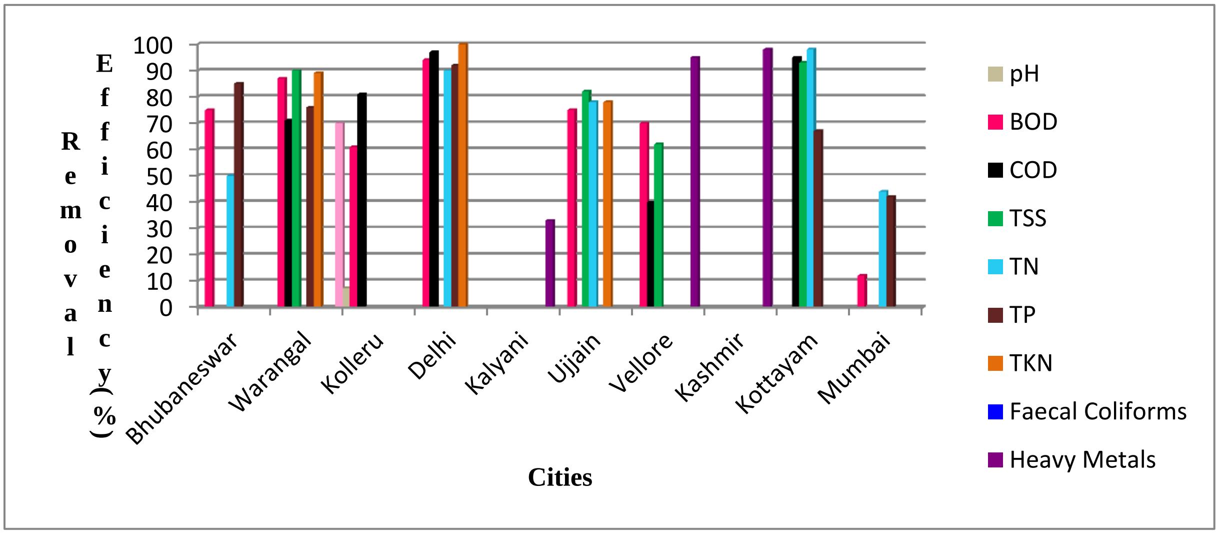


Figure 5: Graph 3 showing a plot between 10 locations in India considered against Pollutant removal efficiency (%)

The removal efficiency of these pollutants is studied at these places and classified similarly as done at the international level and the critical points of the review were discussed below as HF, VF, SSF, Hybrid etc.

Horizontal Flow CWs

A simulated HF CW with Typha latifolia and Polygonum hydropiper was designed to monitor the reduction in nutrient and heavy metal concentration from sewage, showing the concentration of heavy metals in roots of the plants and highest efficiency was observed in T. latifolia as compared to P. Hydropiper with the values as 88,62,72,74 and 67% of BOD, TDS, TSS, $PO_4{}^{3-}$P and TN. Out of the Heavy metals(Zn, Cu, Pb and Cr), Zn was found at the maximum concentration in the roots of T.latifolia and Cr was minimum [Upadhay et al.,2017].

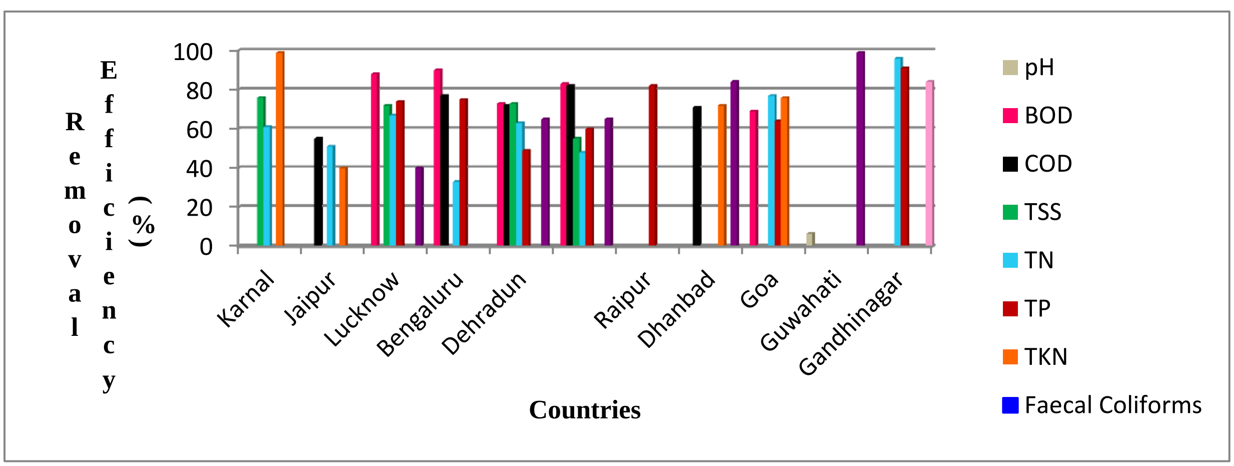


Figure 6: Graph 4showing a plot between the remaining 10 locations in India considered against Pollutant removal efficiency (%)

Vertical Flow CWs

The first CW in India at Sainik school, Bhubasewar planted with Phragmitiscarca and Typha latifolia has shown satisfactory removal efficiency of pollutants with higher rates of removal in P.carca compared to T.latifolia treating domestic wastewater in the order of BOD(75%), TN(50%) and TP(85%) [Juwarkar et al,1995]. A review of the study based on the selection of suitable plant species in semi-arid climatic conditions for quality improvement of treated effluent using Canna indica and Phragmites australis in an up-flow VF CW in Rajasthan showed better removal efficiency of C. indica with TKN(40%), NH_4-N(51%) and indicator organisms coliforms(1.87 log(MPN/100mL)) than P.australis(COD(55%)) [Gargi Sharma and Urmila Brighu,2013]. A comparative assessment between VF and HF CWs using principal component analysis was carried to treat dairy wastewater and simultaneously harvesting plant biomass from units with Typha angustifolia has given improved removal efficiency of pollutants for VF CWs (BOD(83%), COD(82%), TSS(55%), TN(48%), TP(60%), Cr(48%), Fe(69%), Ni(72%)) and this treatment can have multiple uses like nutrient capture, habitat restoration, bioenergy, carbon-offsets and water quality credits [RashiVerma and Surindra Suthar,2018].

Subsurface Flow CWs

An evaluation on the effect of HRT on the treatment of secondary effluent from dairy wastewater in an SSF CW planted with Typha angustata and Scirpus littoralis at a variable HRT (1—4 days) has shown T. Angustata performed better than S. Littoralis with an increase in HRT with the removal efficiency of BOD(94%), COD(97%), TSS(99%), TN(90%), TP(92%), TKN(100%) in which removal of organic pollutants increased three times with an increase in HRT from 1 to 2 days and doubled in 4 days [Deblina Ghosh and Brij Gopal,2010]. SSFCWs combined with Artificial Floating Islands(AFI) were studied in the removal of pollutants and restoration of aquatic systems in which AFI work on hydroponics and planted with Phragmitis karka showing removal rates of BOD(75%), TSS(82%), TN(78%), TKN(78%) [Prashant et al.,2013].

Surface Flow CWs

A pilot SF CW was constructed applying k-C model and monitored for 12 months in Warangal with vascular(macrophytes) and non-vascular(algae) to treat municipal wastewater showed pollutant removal rate of BOD(87%), COD(71%), TSS(90%), TKN(89%), TP(76%), SO_4^{2-}(70%), showing higher removal rate during summer, when the temperature was > 30^0 [Jayakumar and Dandagi,2004]. An analysis of Cd removal in a sewage cum fish farm in a three-stage process of treatment using waste stabilization ponds involving physical, chemical and biological processes using water hyacinth, freshwater bivalve, Lamellidens marginalis were found to be good bio-accumulators of Cd metal in them resulting in overall removal of 33% of Cd from the influent [SukantaRana et al.,2011]. A review on the Natural Treatment Systems(NTS) in 2014 nationwide has shown that out of 108 NTS units working, 23 systems were producing treated effluent fir irrigation in which chlorination may be required. Five NTS based technologies, polishing ponds, waste stabilization ponds, CWs, and Karnal technology, a study in various parts of Central India, Punjab, Haryana have shown that at Ropar, the CW using Typha latifolia for treating primary treated water was found to be the most efficient with no post-treatment required with a removal efficiency of TN(76%), TP(61%) and Faecal Coliform(99%) [D. Kumar et al.,2015].

Horizontal Subsurface Flow CWs

A study of an HSSF CW assessed for the treating Acid Mine Drainage(AMD) using a substrate rich in organic content, with cow manure and bamboo chips using common cattail plants, was found to show a rise in pH from 2.1 to 6.4 and removal of heavy Metals in the order of Cr(99.7)>Ni(97.8)>Co(93.7)>Fe(91.6)>Al(59.7) in percentage and microbial sulphate reduction(44 to 75%) [Shweta Singh and Saswati Chakraborty,2020]. An HSSF CW planted with Axonopus compressus(broadleaf carpet grass) at lab scale was found to be successful in the removal of organic matter and nutrient content in wastewater as Turbidity(93%), COD(95%), No_3-N(98%), Po_4-P(67%) and Anionic Surfactants(95%) in aerobic conditions proving the capability of CWs with carpet grass plantation can be a sustainable method of treating wastewater [ArunBabu et al.,2015].

Vertical Subsurface Flow CWs

A review of a study on the Auxin treatment for wetland (Alternantheraphiloxeroides, Eichhorniacrassipes) and non-wetland(Chrysopogonzizanioides, Festucaarundinaceae) species with natural auxin(Indole-3-acetic acid(IAA) and indole-3-butyric acid(IBA)) and synthetic auxin(1-naphthaleneacetic acid) has shown optimum concentrations of auxins to give maximum removal efficiency of pollutants were 2m/l of IAA, 1mg/l of IAAA and 1mg/l of IBA for A.philoxeroides, F. arundinaceae and C.zizanioides respectively giving an improvement in removal efficiency of auxin treated A.philoxeroides, F. arundinaceae and C.zizanioides for BOD, NO_3-N, PO_4-P as 12-15,30-44, and 29-42% greater than untreated plants [S.A.Tandon et al.,2015].

Lab-scale CWs

A study on the usage of CWs for treating industrial and Agricultural wastewater before disposing the wastewater into Kolleru lake has shown improvement in the quality of treated water which not only helps in the quality of drinking water from the lake, but also saves the lives of many migratory bird species from different parts of the world, conserving Biodiversity, by adopting a lab-scale CW planted with floating, submerged and emergent species showing removal efficiency of pollutants as pH rise up to 7.4, BOD(61%) and COD(81%) [S. Bala Prasad et al.,2010]. A review on a lab-scale CW to treat synthetic greywater using root zone method for the removal of various contaminants using Heliconia angusta revealed that the reduction in them was COD(40), BOD(70), Residual Chlorine(25), TSS(62), TDS(19), TS(46), Turbidity(92), pH(42), Alkalinity(42) in percentage and in vitro metal concentration reduction was Na(98), K(69), Ca(59), Pb(95), Cr(94), Mg(94), Fe(94) in percentage using H. Angusta [S. Saumya et al.,2015]. A study on Phosphorous removal efficiency of laterite soil-based lab-scale CW for treating domestic wastewater monitored for seven months consisting if two reactors R1 planted with10-11 plants /m^2 and R2 planted with 4-5 plants/m^2 using six different species of plants, Typha latifolia, Colocasia esculenta, Alternanthera sessilis Polygonum, Canna indica, Ocimum americanum : L, Pistia stratoites were observed to remove 82% and 76% of soluble P using R1 and R2 respectively showing that higher density of plants removing more nutrients [Kruti Jethwa et al.,2018]. A critical observation of phytoremediation potential of Colocasia esculenta(L) Schott and Typha latifolia L. for treating sewage using CW mesocosms has shown a reduction in EC(71.4), COD(71), TKN(72), Cu(83), Cd(83), Mn(75), Cr(74), Co(84), Zn(66), Pb(78), Ni(80) in percentage, making the treated water suitable for disposal into surface water bodies(according to BIS) [VivekRana and Subodh Kumar Maiti, 2018]. A review of a natural wetland to remove heavy metals(HM) from runoff water using Phragmites australis for phytoremediation showed removal efficiency in the order of Zn(98%), Mo(81%), Ba(78%) and Al(77%) in the roots of the plants helping in reduction of pollutant entry into the environment [Syed Shakeel Ahmad et al.,2014].

Hybrid/Integrated CWs

A review on a work carried to integrate CWs with bioelectrochemical(BES) system which can concurrently treat wastewater effectively with energy recovery and this integrated system utilizes 96.66% of NH_4-N, 83.09% of No_3-N, 91.04% of PO_4-P and 83.98% of So_4^{2-} from wastewater as removal efficiency of contaminants [Manoj Kumar and Rajesh Singh,2020]. Another review on integrated system model to mitigate the water crisis using Treatment plants and CWs along with algal pond integrated with a lake was an innovative, profitable and sustainable technology to remove pollutants using generally used wetland species like Typha sp., Cyperus sp. Water hyacinth along with Algae like Chlorophyceae, Cyanophyceae, Euglenophyseae, Bacillariophyceae helping in the removal of pollutants in the order of BOD(90), COD(77), NO_3-N(33), PO_4-P(75) in percentage and the resulting biomass used to produce energy along with purification process [T.V.Ramachandra et al.,2018]. A study on a hybrid system of VFCWs using Canna indica along with Microalgal Treatment System(MTS) to treat residential wastewater as well as to produce valuable products like Fatty acid Methyl Esters, Ethanol, Biomethane, Biofuel showing removal efficiency of COD(69%), NH_4-N(77%), TKN(76%), PO_4-P(64%) at lab scale [Ram Chavan and Srikanth Mutnuri,2020].

Summary of National Review

In India, most of the work was found to be giving satisfactory results regarding pollutant removal and the majority of it consists of Lab-scale CWs, followed by SF, VF and Integrated or HYB CWs. Removal of pH and Sulphate were included in the study giving satisfactory results. BOD removal was maximum 94%, COD was 97%, TN was 98%, TP was 92% and TKNwas 100% using SSF CW. TSS maximum removal was 93% and that of Faecal coliform was 99% using SF CW. Study of Heavy metals was carried in 8 studies with maximum removal efficiency obtained in HSSF CWs. Sulphate removal was considered in 4 studies and with a maximum removal efficiency of 84% using Lab-scale CW.

Conclusions

A comparative study of International against National contribution in the study of CWs is helpful to understand the current position of India in this field, which was carried by thoroughly analyzing about 130 articles and selecting 20 major publications from various countries as a basis and also in a similar term 20 articles from India from various states gives an idea to a researcher about already focussed areas and that to be focussed in future helping in bringing about quality research in this sector for the betterment of society. The following points were found as some significant findings of the work:

(i) These are the cost-effective, environmentally friendly and efficient in pollutant removal from wastewater.

(ii) HF CWs exhibit compactness in their design

(iii) VF CWs were more effective than HF CWs in the removal of pollutants

(iv) Food stock produced by absorption of nutrients by plants in CW can be used in harnessing Biomass energy to cater to the needs of the society

(v) Removal of Phosphorous is relatively less as compared to Nitrogen in case of HSSF CWs

(vi) Much of the work was not carried on microbial pathogenic removal, i.e. Faecal coliform and pathogenic bacteria

(vii) Integrated treatment technologies like combining CWs along with Algal ponds applied in Jakkur lake near Bengaluru, Bio-electro chemical system and using Hybrid CWs i.e. combining two types of CWs to give benefits of both the types can be also

ISBN: 978-93-90214-19-8

worked on for better results as applied in few IITs in India described in National Review.

(viii) At International level removal efficiency of Sulphate was not considered and Heavy metals were comparatively less against other pollutants, so the future study may be based on this

(ix) At the National level, most of the work was Lab-scale and needs implementation and application in cities and towns, in contrast to most of the developed countries of the world.

(x) Treatment of the pollutants absorbed in soil medium needs to be studied

(xi) The longevity of the bed of a CW also needs to be studied

References

1. Kadlec, R. H. (1995). Overview: Surface flow constructed wetlands. *Water Science and Technology*, *32*(3), 1–12. https://doi.org/10.1016/0273-1223(95)00599-4
2. Vymazal, J. (2011). Water and nutrient management in natural and constructed wetlands. *Water andNutrient Management in Natural and Constructed Wetlands*, 1–330. https://doi.org/10.1007/978-90-481-9585-5
3. Juwarkar, A. S., Oke, B., Juwarkar, A., &Patnaik, S. M. (1995). Domestic wastewater treatmentthrough a constructed wetland in India. *Water Science and Technology*, *32*(3), 291–294.https://doi.org/10.1016/0273-1223(95)00637-0
4. Patil, P. S., Ahirrao, S. P., Chumble, P. V, Navale, M. R., &Mulani, T. N. (2017). *Application ofWetland Ecosystem for Treatment of Industrial Wastewater*. 8911–8916.
https://doi.org/10.15680/IJIRSET.2017.0605273
5. Vasudevan, P., Griffin, P., Warren, A., Thapliyal, A., &Tandon, M. (2011). Localized domesticwastewater treatment: Part I - constructed wetlands (an overview). *Journal of Scientific and Industrial Research*, *70*(8), 583–594.
6. Kickuth, R. (1998). *Chapter 5 HORIZONTAL FLOW CONSTRUCTED*.
7. Mitsch, W. J., & Wise, K. M. (1998). Water quality, the fate of metals, and predictive model validation of a constructed wetland treating acid mine drainage. *Water Research*, *32*(6), 1888–1900. https://doi.org/10.1016/S0043-1354(97)00401-6
8. Konnerup, D., Koottatep, T., & Brix, H. (2009). Treatment of domestic wastewater in tropical, subsurface flow constructed wetlands planted with Canna and Heliconia. *Ecological Engineering*,*35*(2), 248–257.
https://doi.org/10.1016/j.ecoleng.2008.04.018
9. Ji, G. D., Sun, T. H., & Ni, J. R. (2007). Surface flow constructed wetland for heavy oil-produced water treatment. *Bioresource Technology*,*98*(2), 436–441. https://doi.org/10.1016/j.biortech.2006.01.017
10. Fink, D. F., &Mitsch, W. J. (2004). Seasonal and storm event nutrient removal by a created wetland inan agricultural watershed. *Ecological Engineering*, *23*(4–5), 313–325. https://doi.org/10.1016/j.ecoleng.2004.11.004
11. Verhoeven, J. T. A., &Meuleman, A. F. M. (1999). <Verhoeven&Meuleman, 1999.pdf>. *Wetlands for Wastewater Treatment: Opportunities and Limitations*, *12*, 5–12.
12. Neralla, S., Weaver, R. W., Lesikar, B. J., &Persyn, R. A. (2000). Improvement of domestic wastewater quality by subsurface flow constructed wetlands. *Bioresource Technology*, *75*(1), 19–25. https://doi.org/10.1016/S0 60-8524(00)00039-0
13. Rousseau, D. P. L., Vanrolleghem, P. A., & De Pauw, N. (2004). Model-based design of horizontalsubsurface flow constructed treatment wetlands: A review. *Water Research*, *38*(6), 1484–1493. https://doi.org/10.101/j.watres.2003.12.013
14. Gross, A., Shmueli, O., Ronen, Z., &Raveh, E. (2007). Recycled vertical flow constructed wetland (RVFCW)-a novel method of recycling greywater for irrigation in small communities and households.*Chemosphere*, *66*(5), 916–923. https://doi.org/10.1016/j.chemosphere.2006.06.006
15. Morari, F., &Giardini, L. (2009). Municipal wastewater treatment with vertical flow constructedwetlands for irrigation reuse. *Ecological Engineering*, *35*(5), 643–653. https://doi.org/10.1016/j.ecoleng.2008.10.014
16. Masi, F., El Hamouri, B., Abdel Shafi, H., Baban, A., Ghrabi, A., &Regelsberger, M. (2010). Treatment of segregated black/grey domestic wastewater using constructed wetlands in the Mediterranean basin: The zer0-m experience. *Water Science and Technology*, *61*(1), 97–105. https://doi.org/10.2166/wst.2010.780
17. Zhi, W., &Ji, G. (2012). Constructed wetlands, 1991-2011: A review of research development, current trends, and future directions. *Science of the Total Environment*, *441*, 19–27. https://doi.org/10.1016/j.scitotenv.2012.09.064
18. Saeed, T., & Sun, G. (2012). A review on nitrogen and organics removal mechanisms in subsurface flow constructed wetlands: Dependency on environmental parameters, operating conditions and supporting media. *Journal of Environmental Management*, *112*, 429–448.https://doi.org/10.1016/j.jenvman.2012.08.011
19. Madera-Parra, C. A., Peña-Salamanca, E. J., Peña, M. R., Rousseau, D. P. L., & Lens, P. N. L.(2015). Phytoremediation of Landfill Leachate with Colocasiaesculenta, Gynerumsagittatum and Heliconiapsittacorum in Constructed Wetlands.*International Journal of Phytoremediation*,

17(1), 16–24. https://doi.org/10.1080/15226514.2013.828014

20. Rozema, E. R., Rozema, L. R., &Zheng, Y. (2016). A vertical flow constructed wetland for the treatment of winery process water and domestic sewage in Ontario, Canada: Six years of performance data.*Ecological Engineering*, *86*, 262–268. https://doi.org/10.1016/j.ecoleng.2015.11.006
21. García-Ávila, F., Patiño-Chávez, J., Zhinín-Chimbo, F., Donoso-Moscoso, S., Flores delPino, L., &Avilés-Añazco, A. (2019). Performance of Phragmites Australis and Cyperus Papyrus in the treatment of municipal wastewater by vertical flow subsurface constructed wetlands. *International Soil and Water Conservation Research*, *7*(3), 286–296. https://doi.org/10.1016/j.iswcr.2019.04.001
22. Lam, K. L., Zlatanović, L., & van der Hoek, J. P. (2020). Life cycle assessment of nutrient recycling from wastewater: A critical review. *Water Research*, *173*. https://doi.org/10.1016/j.watres.2020.115519
23. *Treatment of Urban Runoff Using Constructed Wetlands in New Delhi, India*. (n.d.).24. Yadav, A. K., Kumar, N., Sreekrishnan, T. R., Satya, S., &Bishnoi, N. R. (2010). Removal of chromium and nickel from aqueous solution in a constructed wetland: Mass balance, adsorption-desorption and FTIRstudy. *Chemical Engineering Journal*, *160*(1), 122–128. https://doi.org/10.1016/j.cej.2010.03.019
25. Malaviya, P., & Singh, A. (2012). Constructed wetlands for management of urban stormwater runoff.*Critical Reviews in Environmental Science and Technology*, *42*(20), 2153–2214. https://doi.org/10.1080/10643389.2011.574107
26. Garrett, B., Shorofsky, B., & Radcliffe, R. (2016). *Evaluation of Textile Treatment and Treatment Alternatives for the Village of Jasol in Rajasthan, India*.1–56.http://www.civil.northwestern.edu/EHE/HTML_KAG/Kimweb/files/FINAL Report for JBF.pdf
27. Singh, S., &Chakraborty, S. (2020). Performance of organic substrate amended constructed wetlandtreating acid mine drainage (AMD) of North-Eastern India. *Journal of Hazardous Materials*, 122719.https://doi.org/10.1016/j.jhazmat.2020.122719 28.*Print_Version_of_CW_Manual-23_May-2019.pdf*. (n.d.).
29. Vymazal, J. (2002). The use of sub-surface constructed wetlands for wastewater treatment in the Czech Republic: 10 years of experience. *Ecological Engineering*, *18*(5), 633–646. https://doi.org/10.1016/S0925-8574(02)00025-3
30. Kyambadde, J., Kansiime, F., &Dalhammar, G. (2005). Nitrogen and phosphorus removal in substrate-free pilot constructed wetlands with the horizontal surface flow in Uganda. *Water, Air, and Soil Pollution*, *165*(1–4), 37–59. https://doi.org/10.1007/s11270-005-4643-6
31. Khan, S., Ahmad, I., Shah, M. T., Rehman, S., &Khaliq, A. (2009). Use of constructed wetland for the removal of heavy metals from industrial wastewater.*Journal of Environmental Management*, *90*(11), 3451–3457. https://doi.org/10.1016/j.jenvman.2009.05.026
32. *Using Constructed Wetlands for Developing Countries.* (2004). 1–11.
33. Tanner, C. C. (1994). Treatment of dairy farm wastewaters in horizontal and up-flow gravel-bed constructed wetlands. *Water Science and Technology*, *29*(4), 85–93. https://doi.org/10.2166/wst.1994.0164
34. Galvão, A., & Matos, J. (2012). The response of horizontal sub-surface flow constructed wetlands to sudden organic load changes. *Ecological Engineering*, *49*, 123–129. https://doi.org/10.1016/j.ecoleng.2012.08.033
35. Sirianuntapiboon, S. (2007). Effect of plantation pattern on the efficiency of subsurface flow constructed wetland (SSF CW) for sewage treatment. *African Journal of Agricultural Research*, *2*(9), 447–454.
36. Schulz, R., &Peall, S. K. C. (2001). Effectiveness of a constructed wetland for retention of nonpoint-source pesticide pollution in the Lourens River catchment, South Africa.*Environmental Science and Technology*, *35*(2), 422–426. https://doi.org/10.1021/es0001198
37. Greenway, M., & Woolley, A. (1999). Constructed wetlands in Queensland: Performance efficiency and nutrient bioaccumulation.*Ecological Engineering*, *12*(1–2), 39–55. https://doi.org/10.1016/S0925-8574(98)00053-6
38. Caselles-Osorio, A., & Garcia, J. (2007). Effect of Physico-chemical pretreatment on the removal efficiency of horizontal subsurface-flow constructed wetlands.*Environmental Pollution*, *146*(1), 55–63. https://doi.org/10.1016/j.envpol.2006.06.022
39. Galletti, A., Verlicchi, P., &Ranieri, E. (2010). Removal and accumulation of Cu, Ni and Zn in horizontal subsurface flow constructed wetlands: Contribution of vegetation and filling medium. *Science of the Total Environment*, *408*(21), 5097–5105. https://doi.org/10.1016/j.scitotenv.2010.07.045
40. Jenssen P, D., &Vrale L. (2003). Greywater Treatment in combined Biofilter/Constructed Wetlands in Cold Climate. *Ecosan – Closing the Loop. Proc. 2nd Int. Symp. Ecological Sanitation, Lübeck*, 875–881.
41. Pandey, M. K., Jenssen, P. D., Krogstad, T., &Jonasson, S. (2013). Comparison of vertical and horizontal flow planted and unplanted subsurface flow wetlands treating municipal wastewater. *Water Science and Technology*, *68*(1ing horizontal flow (HF) and vertical flow (VF) CWs was developed. This paper compares the performance of HF and VF wetlands and planted with unplanted beds. The experimental setup consists of two units of HF and VF

 ISBN: 978-93-90214-19-8

beds of size 6 m× 2 m × 0.6 m and 6 m), 117–123. https://doi.org/10.2166/wst.2013.220
42. Wießner, A., Kappelmeyer, U., Kuschk, P., &Kästner, M. (2005). Influence of the redox condition dynamics on the removal efficiency of a laboratory-scale constructed wetland. *Water Research*, *39*(1), 248–256. https://doi.org/10.1016/j.watres.2004.08.032
43. Ramprasad, C., & Philip, L. (2018). Greywater treatment using horizontal, vertical and hybrid flow constructed wetlands. *Current Science*, *114*(1), 155–165. https://doi.org/10.18520/cs/v114/i01/155-165
44. Upadhyay, A. K., Singh, N. K., Bankoti, N. S., &Rai, U. N. (2017). Designing and construction of simulated constructed wetland for treatment of sewage containing metals.*Environmental Technology (United Kingdom)*, *38A simula*(21), 2691–2699. https://doi.org/10.1080/09593330.2016.1273396
45. Sharma, G. (2013). *Comparison of Different Types of Media for Nutrient Removal Efficiency in Vertical Upflow*.*4*(5), 405–416.
46. Verma, R., &Suthar, S. (2018). Performance assessment of horizontal and vertical surface flow constructed wetland system in wastewater treatment using multivariate principal component analysis. *Ecological Engineering*, *116*(February), 121–126. https://doi.org/10.1016/j.ecoleng.2018.02.022
47. Ghosh, D., &Gopal, B. (2010). Effect of hydraulic retention time on the treatment of secondary effluent in a subsurface flow constructed wetland. *Ecological Engineering*, *36*(8), 1044–1051. https://doi.org/10.1016/j.ecoleng.2010.04.017
48. Prashant, Billore, S. K., Sharma, J. K., Singh, N., & Ram, H. (2013). Treatment of wastewater and restoration of aquatic systems through an eco-technology based constructed treatment wetlands - A successful experience in Central India. *Water Science and Technology*, *68*(7), 1566–1573. https://doi.org/10.2166/wst.2013.401
49. Rana, S., Jana, J., Bag, S. K., Mukherjee Roy, S., Biswas, J. K., GangulyLahiri, S., SarkarParia, D., & Jana, B. B. (2011). Performance of constructed wetlands in the reduction of cadmium in a sewage treatment cum fish farm at Kalyani, West Bengal, India.*Ecological Engineering*, *37*(12), 2096–2100. https://doi.org/10.1016/j.ecoleng.2011.08.002
50. Kumar, D., Asolekar, S. R., & Sharma, S. K. (2015). Post-treatment and reuse of secondary effluents using natural treatment systems: The Indian practices. *Environmental Monitoring and Assessment*, *187*(10). https://doi.org/10.1007/s10661-015-4792-z
51. Arunbabu, V., Sruthy, S., Antony, I., &Ramasamy, E. V. (2015). Sustainable greywater management with Axonopuscompressus (broadleaf carpet grass) planted in subsurface flow constructed wetlands. *Journal of Water Process Engineering*, *7*, 153–160. https://doi.org/10.1016/j.jwpe.2015.06.004
52. Tandon, S. A., Kumar, R., &Parsana, S. (2015). Auxin treatment of wetland and non-wetland plant species to enhance their phytoremediation efficiency to treat municipal wastewater.*Journal of Scientific and Industrial Research*, *74*(12), 702–707.
53. Bala Prasad, S., Ramakrishna Rao, S., &Rahiman, S. A. (2010).Restoration of Kolleru Lake Water Quality Using Artificial Wetland System-a Case Study.*Special Issue*, *3*, 713–720.
54. Saumya, S., Akansha, S., Rinaldo, J., Jayasri, M. A., &Suthindhiran, K. (2015). Construction and evaluation of prototype subsurface flow wetland planted with Heliconiaangusta for the treatment of synthetic greywater. *Journal of Cleaner Production*, *91*, 235–240. https://doi.org/10.1016/j.jclepro.2014.12.019
55. Jethwa, K., Bajpai, S., &Chaudhari, P. K. (2018). *Phosphorus Retention in Lateritic Soil Constructed Wetland Treatment of Domestic Sewage*. *Polomski*, 238–246. https://doi.org/10.1061/9780784482025.025
56. Rana, V., &Maiti, S. K. (2018). Municipal wastewater treatment potential and metal accumulation strategies of Colocasiaesculenta (L.)Schott and Typha latifolia L. in a constructed wetland.*Environmental Monitoring and Assessment*, *190*(6). https://doi.org/10.1007/s10661-018-6705-4
57. Ahmad, S. S., Reshi, Z. A., Shah, M. A., Rashid, I., Ara, R., &Andrabi, S. M. A. (2014). Phytoremediation Potential of Phragmites australis in Hokersar Wetland - A Ramsar Site of Kashmir Himalaya.*International Journal of Phytoremediation*, *16*(12), 1183–1191. https://doi.org/10.1080/15226514.2013.821449
58. Kumar, M., & Singh, R. (2020). Sewage water treatment with energy recovery using constructed wetlands integrated with a bioelectrochemical system. *Environmental Science: Water Research and Technology*, *6*(3), 795–808. https://doi.org/10.1039/c9ew00867e
59. Ramachandra, T. V, Sincy, V., Asulabha, K. S., Mahapatra, D. M., Bhat, S. P., &Aithal, B. H. (2018). Optimal treatment of domestic wastewater through constructed wetlands. *Journal of Biodiversity*, *9*(1/2), 81–102. https://doi.org/11.258359/KRE-180
60. Chavan, R., &Mutnuri, S. (2020). Domestic wastewater treatment by constructed wetland and microalgal treatment system for the production of value-added products.*Environmental Technology (United Kingdom)*, *0*(0), 1–39. https://doi.org/10.1080/09593330.2020.1726471
61. Fountoulakis, M. S., Sabathianakis, G., Kritsotakis, I., Kabourakis, E. M., &Manios, T. (2017). Halophytes as vertical-flow constructed wetland vegetation for domestic wastewater treatment. *Science of the Total Environment*, *583*, 432–439. https://doi.org/10.1016/j.scitotenv.2017.01.090

 ISBN: 978-93-90214-19-8

Adaptive Strategies for Climate Change Mitigation

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Abstract - Climate change has become a global menace. Earth is becoming vulnerable to climate change and warming. There are many causes for this global threat including GHG emissions, increasingly intensive agriculture, deforestation, burning of fossil fuels, transportation, garbage, which in turn releases methane and nitrous oxide gases, fertilizers, and many other natural and anthropogenic factors. Some regions have become vulnerable to droughts, floods, storms, due to the increasing population and adverse effects of climate change. Adaptive strategies, therefore, need to be implemented, which have capacities to mitigate climate change effects. According to IPCC, 2014: Annex II: Glossary, "Adaptation is the process of adjusting to current or expected climate change and its effects".[1] It is one of the ways to counter climate change, in conjunction with climate change mitigation. Adaptation and mitigation are cohering; therefore adaptation strategies shall be synchronized concerning mitigation policies. These policies are the framework for implementation at global, national, regional and local levels following the impacts associated at the respective level. This paper focuses on important strategies along with their functionality and effectiveness towards climate change mitigation. The text will cover the suggestions for effective implementation of the strategies.

Keywords: Climate, Climate change, Climate Policies, Adaptation, Mitigation

Introduction

Climate change refers to the change in the environmental conditions of Earth. However, the climate should not be mistaken for the weather. Weather is the state of the atmosphere at a given time. It describes the degree to which it is hot or cold, dry or wet and it can be measured. It differs from place to place. It might be hot and sunny in one place and could be pouring rain in another. Some people might be enjoying the sun outside and in another region, people might be struggling to shovel the accumulated snow. Whereas, the climate is the long-term weather pattern of a region. Weather can change frequently but climate takes decades, centuries, millenniums or even millions of years to change. Frequent changes in the weather patterns could be an indication and augury of climate change and its effects. The UN says that our world is about 1°C hotter than pre-industrial times, which is around the year 1800. It seems all right. The UN also says that it will still be all right if the temperature rises to 1.5°C or even up to 2°C by the end of the century that is by the year 2100. However, the problem here is the speed of rising in temperature. We are about to hit 1.5°C in only 10 years, that is by the year 2030. If this speed persists, it will prove to be catastrophic. Humankind has already started facing the effects of

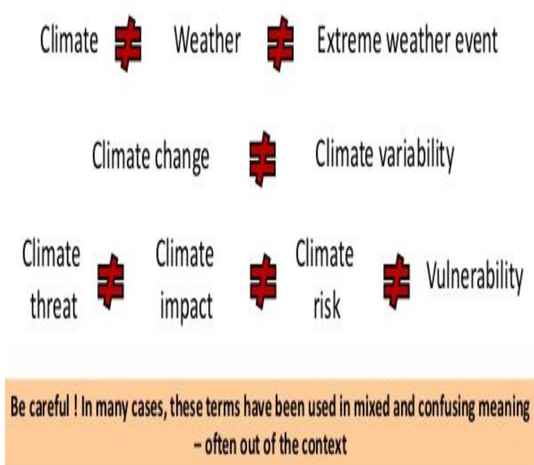

Figure. 1Components of climate change [13] climate change. Pollution, Global Warming, Ozone Layer Depletion, and GHG levels have already elevated. This does not only mean that the Earth's temperature is getting warmer, the massive impacts are social, economical, and physical. The effects include melting of glaciers, the rise of sea levels, irregular weather patterns, longer/shorter seasons, insufficient\excess rainfall, poor air quality, droughts in some regions and floods in some. This calls for the need for Adaptation for Climate Change and its Mitigation.

The Sustainable Developmental Goals 7, 9, 11, and Goal 12 collectively aim to ensure access to affordable, reliable, sustainable and modern energy for all, by 2030 and to upgrade the technology in terms of sustainable energy services and sustainable industrialization in developing countries. Goal 14 and 15 are intended to preserve, rebuild, and encourage sustainable use of terrestrial habitats and maintain forests and aquatic life. Goal 13 aims to take urgent action to combat climate change and its impacts, to strengthen resilience and ability to climate-related threats in all countries, and to embed climate change interventions into national policies, plans and planning.[2]Before our world becomes the victim of our success, we need to act promptly and do our bit to mitigate climate change and follow adaptive strategies.

Literature Reviews

Adaptation will keep on going and changing in continuation with time. It can be considered as a *continuum.* Conceptualization and examination of either mitigation or adaptation are not enough, but a combination of both of these will give the most sustainability and reduce vulnerability.

Rico Kongsager(2018) There is extensive research evidence that both adaptation and mitigation are important to addresssing the climate change scenario. The IPCC estimates that food security and agricultural production are already being affected by climate change. Food demand is increasing due to population growth but simultaneously, crop yields are declining, which pressurizes land fertility and might hike the prices. Studies reveal that forest projects usually do not consider adaptation. The contribution of forests towards rural livelihood is significant. Therefore, forests are central to adaptation.[3]

Jayant Sathaye et al.(2006) Developing countries facing issues related to habitat and soil destruction, freshwater scarcity, food security and air and water contamination. India is a major developing country and nearly two-thirds of the population depends directly on climate-related industry such as agriculture, fisheries and forests. Though India holds over 16% of the global population, and with the evolving energy system around coal, the contribution of India to the cumulative global CO2 emissions from 1980 to 2003 is only 3.11%. But this does not mean that there is no or any lesser need for mitigation and adaptation. India has a significant stake in scientific advancement as well as an international understanding to promote mitigation and adaptation.[4]

Dinar et al.(1998) and Sanghi et al.(1999) The strategy focussed on the Ricardian model investigated the vulnerability of agriculture in developed countries to climate change. The study explores the flexibility of labour-intensive agriculture examining the real production of farms around India and Brazil. The contribution of each factor such as land value, income, land and labour, infrastructure, to the outcome can be measured and the effects of long-term climate change on farm values can be identified. The results of the Ricardian Model show that warming would do less harm than was expected by Agronomic Models because the agriculture models do not involve adaptation. This allows the conclusion that the predictions of the Ricardian model include adaptation competently.[5-6]

***Grubb* (*1989*) and *Mohr* (*1991*)** *argue* that *developing countries may need side payments* to *limit the emission amount of Green House Gases.*[7-8]

Varun Rai et al.(2010) presented a simplified analysis of the viable options in India for Climate Change Mitigation. A graph on 2004 R&D expenditure of India and some other major countries was studied and the study found out that only ten countries spend more than 90% of global R&D expenditure. The study suggests that the successful design of appropriate policies which include economic development and energy security of India will help boost India's credibility and make still deeper cooperation possible in the future.[9]

Isabella Suarez **(2020)** coastal ecosystems which include mangroves, seagrasses, salt marshes serve as natural water filtration systems and marine habitats.

 ISBN: 978-93-90214-19-8

They prevent coasts against the rise of sea level by abating floodwaters and storm surges and store carbon in roots and soil. it is predicted that coastal wetlands have the potential to mitigate one gigatonne of CO_2 per year if they are protected. Road transportation includes about 72% of global transportation-related emissions. this percentage will continue to increase if low carbon emission transportation systems do not become accessible. If public transportation is increased by 40% by 2050 then the number of vehicles on road will decrease and 6.6 Giga-tonnes of carbon dioxide may be avoided. Cities such as Rome and Buenos Aires have other adaptation steps, such as heat proofing buses. Increased usage of public transportation will also improve the air quality as traffic congestion might become less. The idea of public transportation cannot be taken much into consideration as per the current pandemic scenario but it has a lot of potentials if implemented strategically.[10]

Marcel Kok et al. (2008) The focus of people and countries lies mostly only on development, ignoring the severity of climate change causes and effects. If the risks of climate change are not tackled, development efforts will be hampered. Thus, lays a link between development and climate change. It is necessary to enhance the adaptation aspect of the UNFCCC to promote integrated climate and growth approaches to address climate variability and change.[11]

HaraldFuhr et al.(2018) Local governments play a crucial role in achieving the multi-level climate policies made globally. Local and global climate initiatives should be simultaneous and should go hand in hand for effective mitigation.[12]

Strategic and Perspective Planning for Climate Change Mitigation

The two approaches required to tackle climate change are *Mitigation* and *Adaptation.* To minimize the emission levels of GHG will be Mitigation and to live a life by adapting with the climate changes will be an adaptation. Different sectors and groups require adaptation planning about local issues. Systems, sectors, economic groups, communities, have to adapt future changes, which can be climate changes, and not climatic changes, the former including changes in weather patterns, shorter/longer seasons, change in frequency and magnitude of extreme weather events. The latter includes socioeconomic changes, market conditions, government policies, development and infrastructure, migration, etc.

The risks and issues may change their profiles and problems may emerge from change in future conditions of climate and non-climatic changes. These require adaptation and can be beneficially improvised with proper development strategies, innovation, and risk management ideas.

Case studies regarding adaptation strategies for climate change and mitigation across the world could help innovation and improve strategic approach.

1. **Barcelona, Spain:** The trees modulate the climate of the Mediterranean city. The main challenges of climate change include temperature rise, increased droughts, heatwaves and decreased rainfall. Barcelona, for many years, has focused on Aforestation, plantation, and management of trees in an attempt to become a global model of a sustainable city. The Tree Master Plan (2017-37) of Barcelona includes a selection of trees' species, which are water and heat stress resilient, water leakage control, automatic irrigation, increased use of runoff water to water the trees. The budget estimated for this project was EUR 9.6 million/year.[14]
2. **Basel, Switzerland**: An incentive program had been implemented to promote green roofs, as it will serve as both a mitigation attempt and an adaptive strategy to save energy. It will lower indoor temperature and absorb rainwater, reducing flood risk.[15]
3. **Middle Tisza River Basin, Hungary**: The Tisza River has experienced major flooding in past in the year from 1988 to 2000. The region has become more vulnerable to flooding. Climate change is likely to increase this vulnerability. After the flooding events of 1988-2000, the Hungarian Govt. decided to act upon this by focusing weakly on developed areas, strengthening the existing dike system, restoring runoff capacity of flood channels, and making six temporary reservoirs. The reservoirs aimed for agricultural usage during normal times and water retention units during floods. All the reservoirs have been built and one has been used during a flooding event. The cost incurred was around EUR 260 million and has been paid

ISBN: 978-93-90214-19-8

with contributions from the Cohesion Fund and the European Regional Development Fund.[16]

4. **Uttarakhand, India**: The state of Uttarakhand has over 10 million population (Census 2011), the main source of income being rain-fed agriculture. Lack of opportunities and water scarcity has caused many people to migrate to other states. Recently, floods and landslides have been increased in response to erratic rainfalls and temperature rise. In 2014 SAPCC was released by Uttarakhand Govt., by Forest Department with technical support from UNDP, the theme being the transformation of crisis into an opportunity to be more sustainable. Some key departments are undertaking efforts to integrate and reflect adaptation into their work. Disaster Management and Mitigation Centre (DMMC) initiated projects focussing on infrastructure and roads for disaster preparedness. Management Directorate (WMD) had partnered with the World Bank for the Uttarakhand Decentralized Watershed Development Project Gramya to increase efficiency and productivity of rain-fed agriculture. Uttarakhand Housing and Urban Development Authority (UHUDA) is working on building urban resilience as the cities are experiencing a migration of people from rural areas.[17]
5. **Delhi, India:** The capital city of India, Delhi, is already on the list of one of the most polluted cities in the world. Mitigating air pollution and reducing GHG emissions in Delhi is pivotal now. The main factors contributing to the air pollution levels in the capital city are population growth, urbanisation, increased vehicle ownership and industrialization. Air pollution and climate change are related because many air pollutants warm the Earth's surface and some of them cool it. Some air pollutants affect the incoming sunlight, which gets reflected or absorbed by the atmosphere. Climate change indirectly causes malnutrition, diarrhoea, due to food insufficiency and degradation along with improper water system management. The key recommendations to combat climate change in Delhi are to follow pollution control measures to meet National Ambient Air Quality Standards.[48]
6. **Nagpur, India:** A fast-growing Central India metropolitan, Nagpur city mainly depends on major and minor rivers like Kanhan, Pench, and Nag etc. Economic activities, like producing energy at power plants, raising livestock, and growing food crops, require water. The amount of water available for these activities may be reduced as Earth warms and competition for water resources increases. Nagpur following Koppen climate classification has a tropical wet and dry climate, with mostly dry conditions prevailing for most of the year. Nagpur has a climate, which tends to reach extremes. Based on Data provided by NDC from the year 1933 to 2009 it can be observed that the maximum temperature occurrences after 1950 have increased, such extremities are consequences of climate change and disturb the disaster management efforts. The General Circulation Model (GCM) used for this analysis is the T63 variant of the Canadian General Circulation Model. This is a third-generation combined GCM produced at the Canadian Center for Climate Modelling and Analysis (CCCma). The Civic authorities of Nagpur have planned to prepare for a further rise in demand for water supply through the proposed Rahari barrage on Kanhan River, which will satisfy the demand by the Year 2031. Kochi barrage and Jamghat would need to be built to meet water demand for the expected population beyond 2031.[19]
7. The recent outbreak of the novel corona virus, COVID-19, has created havoc and wrecked the world. Millions of lives of people have been affected and the environment too. The positive side seen was the reduction in CO2 emissions, which in turn improved air quality as people worked from home and many industries, road transportation, aviation, and other means of transportation had stopped or reduced. The pollution in China had reduced the carbon emissions by 25% in only four weeks of lockdown. The sustainability of this positive effect is not much because such situations will not always prevail. The world cannot afford to deal with a crisis of climate change or climate-related crisis like tornadoes, wildfires, heatwaves, hurricanes, floods and droughts even when we know how to mitigate and adapt to

climate change. Acting wisely will make a practical present and protected future.[50]

Major Global Strategies Against Climate Change

The International Treaty that addresses climate change, *United Nations Framework Convention on Climate Change* (UNFCCC) was signed by 154 states at the United Nations Conference on Environment and Development (UNCED), which is informally known as the Earth Summit and was held from 3 to 14 June 1992 in Rio de Janerio. The secretariat headquarters was established in Bonn and the treaty was enforced on March 21, 1994. As the name suggests, the UNFCCC's objective is to prevent and minimize climatic emissions and their consequences. One of the first implementations of the UNFCCC was the Kyoto Protocol, signed in 1997 and enforced in 2005. It was later supplanted by the Paris Agreement, which entered into force in 2016. Annually the signatories meet at the *Conference of Parties* (COP) and assess the progress. There are 197 signatories as of 2020.[19-24]

The *Kyoto Protocol* gives target cuts for GHG emissions of the member countries. It gives flexibility in how the targets are met. The gases in the target include carbon dioxide, nitrous oxide, methane, sulphur hexafluoride, hydro fluorocarbons and per fluorocarbons. The mechanisms include International Emissions Trading, Clean Development Mechanism and Joint Implementation. The management of the process of emission monitoring included Registry systems, Reporting, Compliance system and Adaptation.[25]

The core objective of the Paris Agreement is to improve the global response to climate change threats, increase the capacity of countries to cope with climate change effects, and ensure that financing flows are compatible with low GHG emissions and climate-resilient pathway. The l**ong-term temperature objective** is to reduce an increase in temperature and to keep it below 2°C. It establishes binding obligations on all Parties to plan, interact and sustain a Nationally Determined Contribution (NDC). Build a framework to contribute to the reduction of GHG emissions and promote sustainable development. It relies on transparency and an accounting system to give clarity on actions support by the parties. A Global Stock Take is set to take place in 2023 and after every 5 years thereafter to assess the collective progress of the Agreement.[26]

A project under *The Energy and Resources Institute (TERI), aims to set about a research work to enhance the agility and readiness for* **adoption of Modalities, Procedures and Guidelines (MPGs) for the fulfilment of the** Article 13 of the Paris Agreement, which states about Transparency Framework and submission of first Biennial Transparency Report (BTR) from 2024 and henceforth. The goals under this research project are reporting requirements such as common Reporting Tables (CRTs) for GHG inventories, adoption of Modalities, Procedures and Guidelines for tracking progress in implementing and achieving NDCs.[49]

In addition to the Kyoto Protocol and the Paris Agreement, some member parties agreed to further commitments during COP. The other commitments include the Bali Action Plan (2007), the Copenhagen Accord (2009), the Cancun agreements (2010), and the Durban Platform for Enhanced Action (2012).[28]

The *Montreal Protocol* is an International Treaty that was designed to protect the Ozone Layer. It was signed on August 26, 1987, and came into force on August 26, 1989, and was made according to the 1985 *Vienna Convention* for the Protection of Ozone layer. After this Agreement, it was found that the ozone hole in Antarctica was slowly recovering and that the ozone layer will come back to 1980 levels around the year 2050-2070. The Montreal Protocol and the Vienna Convention were ratified by 196 countries, which made them the first universally ratifies treaties in the history of the United Nations.[29]

Every year a *Conference of Parties* is held to assess the progress of the amendments and implementations. At the COP 19 in Warsaw in 2013, a mechanism for Intended Nationally Determined Contributions (INDCs) was created by the UNFCCC, which was to be submitted in the COP 21 in 2015. These INDCs became Nationally Determined Contributions (NDCs) when a country ratified the Paris Agreement in COP21. In the 22nd session of the Conference of Parties (COP22), these NDCs and their implementations were focussed.[30-33]

COP 24 was held in Katowice, Poland (2 to 15 December 2018) and its main goal was to adopt a package of implementing rules for the Paris Agreement- Katowice Rulebook. The main objective was to supervise and promote policies for controlling climate change. With this approach, the member countries agreed to reduce the GHG emissions and anthropogenic causes of climate change. [34]

COP 25 took place in Madrid from 2 to 15 December 2019 and the aim was to recognize the impacts of climate change and the need to cut GHG emissions. [35]

The COP 26 was expected to be held between 9 to 19 November 2020 in Glasgow, UK. However, due to covid19 restrictions and global situations, the COP Bureau, on May 28, 2020, decided that the COP26 would be held from 1-12 November 2021 in Glasgow. [36]

Climate Change Mitigation Strategies: An Indian Scenario

South Asia is substantially and significantly experiencing the effects of global temperature rise caused by climate change. India was ranked as the fourth most affected country by climate change in the period from 1996 to 2015, according to the 2017 edition of the Germanwatch Climate Risk Index. Bangladesh was ranked sixth in the list, followed by Pakistan, which was ranked seventh. Many low lying islands of the Sundarbans region have already submerged due to the rise in sea levels. Among the countries of South Asia, Bangladesh is plausibly the worst affected country by climate change, because of the geographical factors such as low lying, flat and the topography being low lying. Socio-economic factors including, poverty level, increasingly high population density, agriculture dependence. [37-39]

The world is a degree warmer than it was before the industrial revolution. This because of climate change. Author Wallace-Wells says that, if the temperature rises even one more degree, "Cities now home to millions, across India and the Middle East, would become so hot that stepping outside in summer would be a lethal risk." The exposure to heatwaves in India is said to be escalating and will increase 8 times during the year 2021 to 2050. This poses a great risk to human civilisation, farm labour productivity. Indian's exposure to heatwaves has increased by 200% from 2010 to 2016. For the first time in history, a heatwave in Kerala was reported in 2016. 36 people died in 2019 because the temperature rose to 50.6°C. Not only day temperatures but night temperatures also have increased. New Delhi broke its record with a high temperature of 48°C. 11 of the 15 warmest years on record have occurred since 2004. [40]

As the average temperature increases, sea levels are rising due to the melting of ice and glaciers, also, if the temperature is more, evaporation will be more and thus increase the amount of precipitation. But increase in precipitation does not necessarily mean that the availability of water for, drinking purposes, industrial usage, irrigational purposes, and other usages will increase. Indian economy highly depends on agriculture, and indirectly on proper monsoon patterns. Arvind Subramanian, an Indian economist and the former Chief Economic Adviser to the Government of India had estimated that farmer's income will be reduced by 15-18% and around 20-25% in un-irrigated areas, because of climate change.[41]

As of 2020, around 40% of people in India were employed in the agricultural sector. This indicates the dependency on agriculture. The agricultural sector is vulnerable to climate change and erratic monsoon adds to it. National Innovations in Climate Resilient Agriculture (NICRA) project's analysis shows that climate change will affect rain-fed agriculture and particularly, crops like rice, maize and wheat.[42]

The global population is expected to increase by a billion by 2030 and up to 9.7 billion by 2050. The Indian population is expected to increase from 1.36 billion in 2019 to 1.5 billion by 2030 and up to 1.64 billion by 2050. Providing an adequate amount of nutrition and food to the population needs serious and proper and effective planning along with implementation and adaptation. Climatic factors like irregular rainfall, inappropriate temperatures will affect food production. It may also affect soil fertility, crops, animal husbandry, fisheries and availability of water. There are a lot more sufferings that climate change will cause which shows that addressing and adapting the climate change issue is paramount. [43]

Indian Initiatives

At the Climate Action Summit in New York, Prime Minister Shri Narendra Modi announced a climate change mitigation plan with the key points of sustainable mobility, use of electric vehicles, renewable energy, use of solar energy, and low carbon pathways.[44]

1. India aimed to cut its emission intensity by 33-35% by 2030, as compared to 2015 levels and to produce 40% of the energy by non-coal sources. The challenge lies in reducing coal-based energy emissions by the use of other means of energies like solar energy, wind energy, hydroelectric power, etc.[45]
2. National Targets for Renewable Energy were/are:
   - 2.1. Renewable capacity: 12.5 GW installed in 2007-2012; 15% of the additional power capacity (2002-2022)
   - 2.2. Solar Photovoltaic and CSP: 1.1 GW by 2013; 10 GW by 2017, 20 GW by 2022
   - 2.3. Wind power: 9 GW scaled in (2007-2012)
   - 2.4. Small hydro power plant: 1.4 GW augmented in (2007-2012)
   - 2.5. Biomass/cogeneration: 1.7 GW installed in (2007-2012)
   - 2.6. In 2007-2012, 0.4GW power generation was added through Waste-to-energy
   - 2.7. Solar hot water: 15 million m^2 by 2017; expected to be 20 million m^2 by 2022
   - 2.8. Rural lighting systems: 20 million by 2022 [46]
3. Missions of the National Action Plan on Climate Change are
   - 3.1. National Solar Mission: 20,000 MW of Solar power by 2020
   - 3.2. National Mission for Enhanced Energy Efficiency: 10,000 MW of energy savings by the end of 11th FYP in 2012
   - 3.3. National Mission on Sustainable Habitat Energy: Efficient buildings, transport, waste management systems, energy efficiency as an integral component of urban planning, improving the resilience of infrastructure, community-based disaster management, capacity building
   - 3.4. National Water Mission: The water use efficacy would be increased by 20% through regulatory framework with unequal entitlements and pricing; formulating basin-level management plans, and establishing water saving initiatives
   - 3.5. National Mission for preserving the Himalayan Ecosystem: Understand the glacial shift through glacial observation, participatory management of Himalayan ecosystems
   - 3.6. National Mission for a Green India: 6 million hectares of forestation over polluted land by the end of the 12th Five-year plan (2017)
   - 3.7. National Mission for Sustainable Agriculture: Famine proofing, climate risk management, improved productivity of rain-fed agriculture
   - 3.8. National Mission on Strategic Knowledge for Climate Change: Evaluate risk and identify solution to climate change through high quality and focused R&D[47]

The need for Specific Strategies in India:

Both India and other developing countries, it is important that mitigation does not overshadow other key parameters of the Paris Climatic Accord. There has been biased treatment of adaption, which is a great challenge for most developing countries such as India than mitigation is. We are already feeling the consequences of climate change. The GHG, which accumulated, will diminish slowly from the atmosphere; therefore, the mitigation should be shouldered equally by all such countries.

India needs to step up with climate change policies that have been implemented by UNFCCC and the policies, which are undergoing nationally. Climate change adaptation strategies requires long-term goals. The governments tend to focus on short-term goals and might give a prime focus on development and *quick fixes*. All the states need to optimally analyse and carry through the policies that have been framed and strategies made for adaptation. The government of India should be open to innovative ideas for and from the people for the same. People's participation is inevitable in combating with climate change effects. The *Numero Uno* goal is to reduce fossil fuel dependency.

Government of India should encourage the Green buildings Concept in all of its government constructions, implement Transit Oriented

 ISBN: 978-93-90214-19-8

Development (TOD) concept in major cities, especially all metro cities. India is becoming a 'Concrete Jungle' by virtue of Cement Concrete Road construction in many parts of the country, including national and state highways, expressways, etc. even the concrete roads are constructed in rural part of the country, which need to revisit. The government of India recently announced the vehicle scrap policy, which a welcome step to reduce the vehicular pollution caused by old motor vehicles.

India is a country of cultural heritage. Many languages and customs are deeply rooted in the life of people of India. Though respecting the culture, celebrating the occasion is a part of lifestyle; but people, at the same time, must respect the nature and our ecosystem. It is our foremost and important duty to see that the healthier environmental conditions are preserved by the activities we undertake during the celebration of our cultural heritage. Needless to say that we have been looking at industrial development and rapid urbanization as key factors responsible for environmental degradation; however, myriad customs, rituals, celebrations, etc are also contributing to the cause. Therefore, efforts of every citizen in combating climate change effects are counted besides their routine lifestyle.

We as citizens concerned for our environment and better future must contribute towards mitigation and adaptation, only then the policies come into fruition. We can help in many ways like using only the required quantity of water, globally, people tend to take water availability for granted and waste it like it is never-ending and accessible in abundance. Do not waste water while brushing, washing clothes and utensils; do not pollute natural water resources by considering them as our own. Celebrate festivities in an eco-friendly manner. Turn off the lights and fans when we leave the room or when not in use. Little knowledge is a dangerous thing; wisely said, educating ourselves about the Earth, its resources, climatic issues and sustainable living will help a lot. The plantation is very crucial and beneficial. Plant trees and do water them. We need to be a part of the solution and not a part of pollution. We can adapt the use of E-vehicles, prefer commuting by cycle when and if possible. Minimize the use of plastic, increase solar dependency. The global livestock industry produces more GHG emissions than cars, ships, planes produce it combined, optimise our diets if possible. Respect and protect green spaces. Talk about the changes we make. We need to understand that we do not inherit the earth from our ancestors, we are borrowing it from our younger generations.

Conclusion

Anthropogenic factors have contributed to climate change across the globe. The adverse effects of climate change will continue to occur in both predictable and unpredictable ways. To avoid the worst predicted impacts, individuals need to act now. If contemplated from a broader perspective, all-weather changes and events have a connection with climate change. The required adaptation is not occurring and needs to be boosted to reduce vulnerability. Future risk depends on climate change and the course of growth. We would need a combination of adaptation and mitigation strategies to address the threat of climate change and to mitigate the humankind and the environment harm because of climate change.[51-54]

References

1. *IPCC (2014). "Glossary" (PDF). Intergovernmental Panel on Climate Change*
2. *A global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development, A/RES/71/313 E/CN.3/2018/2 E/CN.3/2019/2 E/CN.3/2020/2, Goal 7, Goal 9,Goal11,Goal12,Goal13,Goal14,Goal15. https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202020%20review_Eng.pdf*
3. *Rico Kongsager(2018) Linking climate change adaptation and mitigation: A review with evidence from Land-UseSectors,7158,https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.mdpi.com/2073-445X/7/4/158&ved=2ahUKEwjMrM2G2a_tAhWnyDgGHYXhCa4QFjAFegQICRAM&usg=AOvVaw35DosIMK0jfxgRXZGidhkB*
4. *Jayant A. Sathaye, Kenneth Andrasko, Willy Makundi, Emilio Lebre LaRovere, N.H. Ravindranath, Anandi Melli, Anita Rangachari, Mireya Imaz, Rafael Friedmann, Beth Goldberg, Clive van Horen, Gillian Simmonds, Gretchen Parker (2006) Climate change, sustainable development an India: Global and national concerns, Current Science, Special*

ISBN: 978-93-90214-19-8

section: climate change and India, 314-325 https://www.researchgate.net/publication/237247341_Climate_change_sustainable_development_and_India_Global_and_national_concerns

5. Dinar, Ariel, Robert Mendelsohn, Robert E. Evenson, Jyoti Parikh, Apurva Sanghi, K. Kumar, James McKinsey, and Stephen Lonergan, eds. 1998. Measuring the Impact of Climate Change on Indian Agriculture. World Bank Technical Paper 402. Washington, D.C.
6. Sanghi Apurva, and Robert Mendelsohn. 1999. "The Impact of Global Warming on Brazilian and Indian Agriculture." Yale School of Forestry and Environmental Sciences, New Haven.
7. Grubb, M. J. (1989). The greenhouse effect: Negotiating targets. London: The Royal Institute of International Affairs.
8. Mohr, E. (1991). Global warming: Economic policy in the face of positive and negative spillovers. In H. Siebert (Ed.), Environmental scarcity: The international dimension (pp. 189-212). Kiel: InstitutfuerWeltwirtschaft an der Universitaet, J.C.B. Mohr, Tuebingen.
9. Varun Rai and David G. Victor (2010) Identifying Viable Options in Developing Countries for Climate Change Mitigation: The Case of India. International Association for Energy Economics, First Quarter, 09-13, https://www.iaee.org/en/publications/newsletterdl.aspx?id=90
10. Isabella Suarez, February 2020,5 Strategies that Achieve Climate Mitigation and Adaptation Simultaneously. https://www.wri.org/blog/2020/02/climate-change-mitigation-adaptation-strategies
11. Marcel Kok, Bert Metz , Jan Verhagen , Sascha Van Rooijen (2008) Integrating development and climate policies: national and international benefits. Synthesis article, climate policy. https://www.tandfonline.com/doi/abs/10.3763/cpol.2007.0436
12. HaraldFuhr, ThomasHickmann, KristineKern (2018), Elsevier, The role of cities in multi-level climate governance: local climate policies and the 1.5 °C target, Current Opinion in Environmental Sustainability Volume 30, Pages 1-6.
13. SEA START AC Copyright 2017 https://image.slidesharecdn.com/climatechangeadaptationchinvanno-170802013852/95/climate-change-adaptation-principle-and-perspectives-from-thailand-supakorn-chinvanno-4-638.jpg?cb=1501638067
14. Climate-ADAPT— Sharing adaptation information across Europe European Climate Adaptation Platform,Casestudy2,https://climate-adapt.eea.europa.eu/about/climate-adapt-10-case-studies-online.pdf
15. Climate-ADAPT—Sharing adaptation information across Europe European Climate Adaptation Platform,CaseStudy3,https://climate-adapt.eea.europa.eu/about/climate-adapt-10-case-studies-online.pdf
16. Climate-ADAPT—Sharing adaptation information across Europe European Climate Adaptation Platform,CaseStudy10,https://climate-adapt.eea.europa.eu/about/climate-adapt-10-case-studies-online.pdf
17. Ayesha Dinshaw, NamrataGinoya, ParvathiPreethan, ArivudaiNambiAppadurai, MarinangelesGutiérrez Rivera. Mainstreaming Adaptation In Action: Case Studies From Two States In India, World Resource Institutehttps://files.wri.org/s3fs-public/mainstreaming-adaptation-action-case-studies-two-states-india.pdf
18. Shravan Kumar S M, Dr A. D. Vasudeo, Climate Change and its Impact on Nagpur's Water Supply, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 IJERTV4IS100152, Vol. 4 Issue 10, October-2015 https://www.ijert.org/research/climate-change-and-its-impact-on-nagpurs-water-supply-IJERTV4IS100152.pdf
19. World Health Organization (WHO). Retrieved 22 October 2020." United Nations Framework Convention on Climate Change (UNFCCC)".
20. 29 September 2014 at the WaybackMachine Chapter 13 in Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge

University Press, 2014 R. Stavins, J. Zou, et al., "International Cooperation: Agreements and Instruments." Archived

21. *Climate Leaders. Lead India. 2009. Archived from the original on 27 March 2009. Retrieved 5 December 2009. "What is the UNFCCC & the COP".*
22. *The United Nations Framework Convention on Climate Change. Retrieved 23 May 2016, (PDF). "Article 2"*
23. *H.K., Jacobson (2001). Science Direct. Retrieved 22 October 2020." United Nations Framework Convention on Climate Change: Climate Policy: International".*
24. *Schiermeier, Quirin (2012). "The Kyoto Protocol: Hot air". Nature. 491 (7426): 656–658. Bibcode:2012Natur.491..656S. doi:10.103 8/491656a. PMID 23192127. S2CID 4401151.*
25. *UN Treaty Database. Retrieved 27 November 2014. "7 .a Kyoto Protocol to the United Nations Framework Convention on Climate Change".*
26. *United Nations Treaty Collection. 8 July 2016. Archived from the original on 21 August 2016. Retrieved 27 July 2016." Paris Agreement".*
27. *ABC News. Archived from the original on 4 November 2016. Retrieved 4 November 2016. "Paris Climate Agreement Becomes International Law"*
28. *UNFCCC initiatives, Other decisions, WikipediaCOP 2008 COP 2010, COP 2011 COP 2012*
29. *H.K., Jacobson (2001). Science Direct. Retrieved 22 October 2020 "United Nations Framework Convention on Climate Change: Climate Policy: International"*
30. *Climate Policy Observer. Archived from the original on 11 February 2017. Retrieved 23 January 2017. "INDC - Climate Policy Observer".*
31. *Ad Hoc Working Group on the Durban Platform for Enhanced Action Second session, part seven Archived 1 October 2016 at the Wayback Machine, UNFCCC, Geneva, 12 December 2014*
32. *Change, United Nations Framework Convention on Climate. unfccc.int. Retrieved 23 January 2017. "NDC registry".*
33. *"United Nations Treaty Collection". Retrieved 23 January 2017*
34. *COP24, Katowice, 2018. UnitedNations Framework Convention on Climate Change(UNFCCC) https://cop24.gov.pl/*
35. *COP25 UN Climate Change Conference December 2019 https://unfccc.int/cop25*
36. *SDG Knowledge Hub, IISD, UN Climate Change Conference (UNFCCC COP 26)https://sdg.iisd.org/events/2020-un-climate-change-conference-unfccc-cop-26/*
37. *Kreft, Sönke; David Eckstein, David; Melchior, Inga (November 2016). Bonn: Germanwatch e.v. ISBN 978-3-943704-49-5. Archived from the original (PDF) on 25 September 2017. Retrieved 10 July 2017 Global Climate Risk Index 2017*
38. *Ayers, Jessica; Huq, Saleemul; Wright, Helena; Faisal, Arif M.; Hussain, SyedTanveer (2014-10-02). "Mainstreaming climate change adaptation into development in Bangladesh". Climate and Development.* ***6*** *(4):293–305. doi:10.1080/17565529.2014.977761. ISSN 1756-5529. S2CID 54721256.*
39. *Thomas TS, Mainuddin K, Chiang C, Rahman A, Haque A, Islam N, Quasem S, Sun Y (2013). Agriculture and Adaptation in Bangladesh: Current and Projected Impacts of Climate Change(PDF) (Report). IFPRI. Retrieved 26 November 2020.*
40. *The Wire. Retrieved 2020-10-30. "2018 Was Sixth Warmest Year in India's Recorded History: IMD".*
41. *The Wire, Science, Environment, Climate Change Means Erratic Monsoons, and Erratic Monsoons Come at a High Cost (14/05/20) https://science.thewire.in/environment/climate-change-india-rainfall-monsoons/*
42. *AnishChatterjee, Climate Change and Indian Agriculturehttps://www.devalt.org/newsletter/nov03/of_5.htm*
43. *The Wire, Agriculture, Opinion, Climate Change Poses Serious Threats to India's Food Security(19/Sep/2019)https://thewire.in/agriculture/climate-change-poses-serious-threats-to-indias-food-security*
44. *Anjali Jaiswal, Sameer Kwatra,* ***Madhura Joshi****. (September 23, 2019) Lead Energy Access and Climate Policy Consultant, NRDC*

India Initiative, India Announces Stronger Climate Actionhttps://www.nrdc.org/experts/sameer-kwatra/india-announces-stronger-climate-action

45. D. Balasubramanian, November 9, 2019, The Hindu, Speaking of Science**,** India's efforts towards mitigating climate change. https://www.thehindu.com/sci-tech/science/indias-efforts-towards-mitigating-climate-change/article29931763.ece
46. *Renewables2010 Global Status Report*
47. *National Action Plan Climate Change (NAPCC) (2008). Government of India.*
48. ***Hem HimanshuDholakia, Amit Garg****, Dholakia, H.H., and A Garg. 2018. "Climate Change, Human Health and Air Pollution in Delhi, India" In Climate Change and Air Pollution, Akhtar&Palagiano (Eds). Springer Climate. Springer, Cham. council on energy, environment and water integrated, international, independent. Risks & Adaptationhttps://www.ceew.in/publications/climate-change-air-pollution-and-human-health-Delhi-india*
49. *Mr Abhishek Kaushik (01 Sep 2019)Preparedness towards implementing Enhanced Transparency Framework and tracking NDCs under the Paris Agreement, TERI, Creating Innovative Solutions For A Sustainable Future https://www.teriin.org/project/preparedness-towards-implementing-enhanced-transparency-framework-and-tracking-ndcs-under?utm_campaign=9783898964&adgroupid=109284192179&utm_content=464292760065&utm_term=india%20pledge%20paris%20agreement&gclid=Cj0KCQiAhP2BBhDdARIsAJEzXlH7ZyGPsQje5gGCThLFEcDc1-1Ad5wpX-8scZP72FspKLSDJ8xAqgIaAiKqEALw_wcB*
50. *Jason ParejaJauregui, What is the Effect of COVID-19 on Climate Change, One Young World https://www.oneyoungworld.com/blog/what-effect-covid-19-climate-change*
51. *IPCC, 2007(a): Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P.Palutikof, P.J. van der Linden and C.E. Hanson (Eds.), Cambridge University Press, Cambridge, United Kingdom, 976 pp.*
52. *IPCC, 2007(b): Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.V. Avery, M. Tignor and H.L. Miller (Eds), Cambridge University Press, Cambridge, United Kingdom, and New York, USA, 996 pp.*
53. *IPCC, 2007(c): Climate Change 2007: Synthesis Report. IPCC, Geneva, Switzerland, 102 pp.*
54. *World Meteorological Organisation, Key IPCC Conclusions on Climate Change Impacts and Adaptations, Vol 57 (2) 2008https://public.wmo.int/en/bulletin/key-ipcc-conclusions-climate-change-impacts-and-adaptations*

A Critical Review on Application Areas of Computational Fluid Dynamics in Context to Environmental Pollution

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Abstract - It is due to recent applications of the Computational Fluid Dynamics (CFD) entered in the domain of Environmental engineering, the objective of the present article is to study and discuss the various applications of CFD, in particular, the behaviours of fluids and gases in context to environmental pollution. The present article focuses on the specialized area such as air pollutants, UV light for the disinfection and UV light as oxidation and its application with respect to CFD modelling. A critical review has been presented among these areas to address the modelling capabilities with CFD and its working principle.

Keywords: Computational Fluid Dynamics, Partial differential equation, Reynolds Navier stokes equation.

Introduction

Due to rapid industrial growth, vehicular emission and industrial as well as household activities, the quality of water and air gets degraded continuously, such activities produce waste water and air pollutants that pollutes the atmosphere and natural streams, wherein the protection and conservation of the natural resources has become one of the major focus of research across the globe.
By applying proper and careful treatment to such waste water and air pollutants before discharges them into atmosphere, natural resources and environment can be protected from such pollutants.Various conventional methods and advanced methods has been developed for the treatment of these waste water and air pollutants, which are discussed here in this paper to address and explore the applicability of such methods to reduce the air and water pollutant discharges.
It is necessary to perform the number of experiments on such fluids (water water samples as well as air pollutant samples to decide the proper treatment options, dosage of chemicals etc. The amount of time and cost of these experiments are huge, in view of this, computational method is visible option to minimize this experimental time and cost. Computational Fluid Dynamics modelling is very much essential this regard and to address the solutions those are related with the environmental issues.

Computational Fluid Dynamics (CFD) is a branch of science, which describes the behavior of fluid (liquid and air)in different flow conditions. CFD also describes different chemical reac- tors and influence of the hydraulics on physical, chemical and biological process taking place in a reactor. Mainly, it is a computational technique which estimate the different flow parameters in actual environmental condition.

Basically,CFD is a numerical technique which solves the equations of fluid dynamics over space and time. These fluid dynamics equations are mainly working on the principles of conservation of mass, conservation of momentum and conservation of energy. CFD can simulate and predict the complex flow pattern with ease and faster than complex experimental work.The benefits of CFD over experimental analysis are listed here:

- Experimental techniques works with limited number of variables measured simultaneously, while CFD allows a large number of variables to be measured at the same time.

- Experiments may be performed on scaled models, whereas CFD allows full scale predic- tions.
- Once an experimental set-up is fixed, the geometry cannot be changed, which can be changed easily in CFD
- All the realistic conditions can be incorporated in CFD analysis, which is not possible in experimental analysis.
- Experimental techniques are very expensive and time consuming whereas CFD simula- tions are relatively cheap and less time consuming.

1 How Computational Fluid Dynamics (CFD) Works

Partial differential equations (PDE) describes most of the engineering problems but closed- form solutions of the governing partial differential equations are available only in few cases.so, such problems can be solved by the numerical methods. Different numerical methods are avail- able for the solution of such PDE. Among these different numerical methods, finite difference method, finite volume method and finite element methods are most popular.

CFD is a numerical method, which solves a set of differential equations describing a fluid behavior and its phenomenon.Generally Reynolds Average Navier Stokes (RANS) equations are used to describe this fluid phenomenon.CFD analysis includes modelling of the geometry, grid generation, apply initial condition and boundary condition. Then set of differential equation are solved and required results are obtained.

Computational methods like finite difference methods, Finite Volume Method or Finite El- ement methods, discritized the entire domain into small size elements. Elements should be finer enough to get better convergence of the problem as the exact solution. The elements are small enough such that the different flow parameters assumed to be constant over an element. The value of the flow parameters can be obtained by different approach based on the methods selected.[1]

Finite Difference Method is a simplest approach for solving PDEs. It divides the domain in rectangular elements only. This method is not appropriate for the irregular shape. Such diffi- culties can be overcome usinf FVM and FEM. FEM is most appropriate method for solving the problems with complicated geometry and diffident material property as elemental variation can be easily incorporate with it.The points of the intersection of the straight lines are called mesh points or grid points or more commonly known as nodes. This is known as grid generation.[1]

Basically CFD will solve the partial differential equation for each discretised element of fluid particle. The numbers of equations generated are equal to the number of unknowns depending on the number of mesh points.[2]

2 Literature Reviewed

The application of the Computational Fluid Dynamics in various Environmental Engineering prospects has been reviewed as per following.

2.1 Reviews on mixing effects in CFD

Khandve.et.al presented various application of CFD in environmental Engineering perspective. Author showed the pictorial view of flow path lines in flocculation tank, residence time in basins with different colour ribbons, velocity contours for ozone contact chamber, flow through the different oxidation tanks & weirs, particle distribution over an electrostatic precipitator, inciner- ator and many more. Author had also described the process and methodology of Computational Fluid Dynamics.Authors have described other applications as building construction, Geotechni- cal engineering, Hydraulic Engineering, Material science, Structural Engineeing, Transportation Engineering, Wind Engineering,etc. [3]

Laurent.et.al showed application of Computational Fluid Dynamics for modelling waste wa- ter treatment plant. Author simulated physical, chemical and biological processes involved in waste water treatment plants using FLUENT and also approached step wise analysis using $k-\varepsilon$ model and Reynolds's stress model.[4]

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Jaiklom.et.al. showed the effect of jet mixing in a tank. Authors further applied different jets at centre and corner in tank and their mixing efficiency was worked out by computational fluid dynamics. Authors had validated their results with experiments. Result proved that free jet flow with tracer injection at the centre position gives the better mixing time as compared to wall jet. This is due to the high entrainment rate of straight jet stream, which makes the circulation of bulk fluid.[5]

Irfan.et.al studied performance of CFD for the mixing of two liquids without use of stirrers.[6] Marek.et.al demonstrated the mixing effect through jet in a water storage tank with varying the jet velocity, nozzle diameter and nozzle angle.[7] Rajavathsavai.et.al showed mixing behaviour of continuous stirred tank reactor mainly used in chemical industries.[8].Aubin.et. al showed effect of multiple impeller stirred tank for the mixing of highly viscous fluid.[9] Ochieng.et. al has shown mixing efficiency in a stirred tank

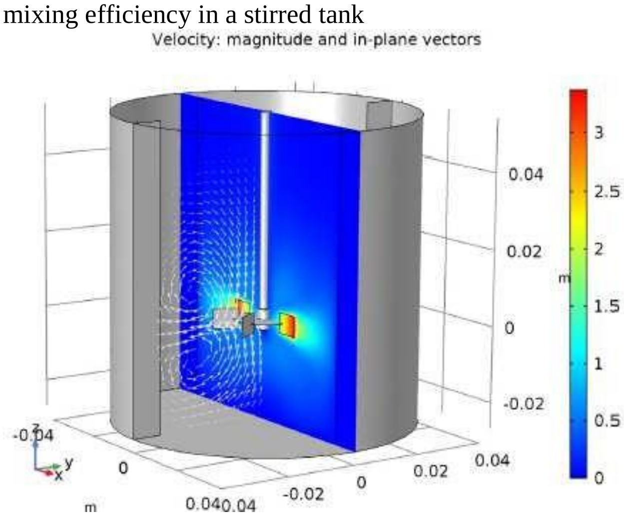

Figure 1: Velocity profile of in Completely mixed tank over the traditional methods which lead to lower power consumption.[10]

Paravareh.et. al showed the mixing efficiency in different jet positions. Authors had performed experiments by injecting dye in a tank and its mixing efficiency found with different jet positions and found that jet nozzle position at 90° with respect to horizontal tank position is most suitable for proper mixing of dye using CFD. Authors had validated the predictions by experimental tank with different nozzles. [11]

Zhang showed his work in fluid hydrodynamics in continuous stirred tank and predicted their mixing efficiency using CFD. Franco also showed CFD simulations for parallel reaction scheme in an un-baffled vessel.[13]

Farbod.et.al predicted effect of flow rate and jet angle on mixing time considering different jet angles.[12]
Such kind of proper mixing with a rotor at a center can be visualised as shown in figure 1
F. Solano.et.al showed the water quality inside the drinking water storage tank using FLU- ENT model which affect the water quality in distribution system. Authors had used the trans- port of trace element with advection-diffusion equation.[?]

2.2 Reviews on solid suspension in water

Ochieng.et. al showed CFD simulations for Solid suspension. Authors had developed model for solid liquid mixing and predicted for solids off-bottom suspension, solids concentration and particle size distribution and cloud height.[14]Sendilkumar.et. al showed mixing characteristics in jet mixer for Newtonian and non-Newtonian fluids.[15]

Mikhail showed importance of CFD in entire water systems. Author had showed CFD mod- elling in mixing chemicals with water, improvement in pumping efficiency. Moreover, author had developed CFD models for bio-reactors and Ultraviolet disinfection process in the water industry.
Choi.et. al showed variations in residence time distribution in stirred tank and developed model for reactor with and without baffled condition. [16]

Bridgeman et al showed CFD modelling for flocculation in water treatment. [17]

2.3 Reviews on Disinfection and Pollutant reduction in CFD

Peres.et. al simulated photo reactor in CFD under ultraviolet lights. Author had predicted Phenol oxidation under UV light and Hydrogen Peroxide in different variations of Phenol con- centration, Hydrogen Peroxide and Phenol ration, lamp electric

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power, swirling velocity field, residence time by standard $k - \varepsilon$ turbulent model. These results were validated with experi- mental data.[18]

Moghaddami.et. al also predicted the performance and energy consumption of photo reac- tor under ultra violet and Hydrogen Peroxide in CFD. [19]
Saha.et. al predicted disinfection of waste water under ultraviolet light in open channel.[20]

Kenny.et. al predicated the flow in neutralization tank. Author has predicted its performance of scale formation in the tank after applying Lime to Acid mine drainage as well as proper mixing efficiency of lime and Acid mine drainage.[21]
Harris.et. al reviewed flow in baffled stirred tank and predicted role of temperature profile and residence time distribution in required product by using Computational Fluid Dynamics.[22]

Pochai.et.al showed mathematical model of water pollution control using the finite element method. Authors had modelled the dispersion of COD concentration in river. Authors also took different variables as velocity, dispersion rate and substance decay rate and model them in Finite element method with proper initial conditions and boundary conditions.[23]

CFD analysis with a plug flow reactor has been carried out as shown in figure 2. Here, in Plug flog reactor with a baffles create the turbulence in the flow and proper mixing of chemicals with waste water has been carried out. Such variation in velocity flow can be easily visualized with color chart.
Korbahti showed modelling of continuous flow tubular electrochemical reactor for industrial and domestic waste water treatment. Author had also showed the COD reduction by consid- ering the different parameters like COD concentration, flow rate, diffusion coefficient of waste water, reaction rate constant and reaction order.[24]

Wright.et.al used the CFD in the evaluation of UV based water treatment systems and eval- uated maximum dosage and particle tracking. Moreover, authors had showed the sensitivity of model selection and dosage concentration with different plots.[25]

Wols.et.al used the COMSOL multiphysics software for the disinfection of water drinking water systems.[26]

Sun.et.al showed the transport of Calcium Carbonate in UV disinfection system using CFD in water treatment systems using COMSOL multiphysics.[27]

Souza.et.al showed residence time distribution in the tubular reactor using COMSOL mul-

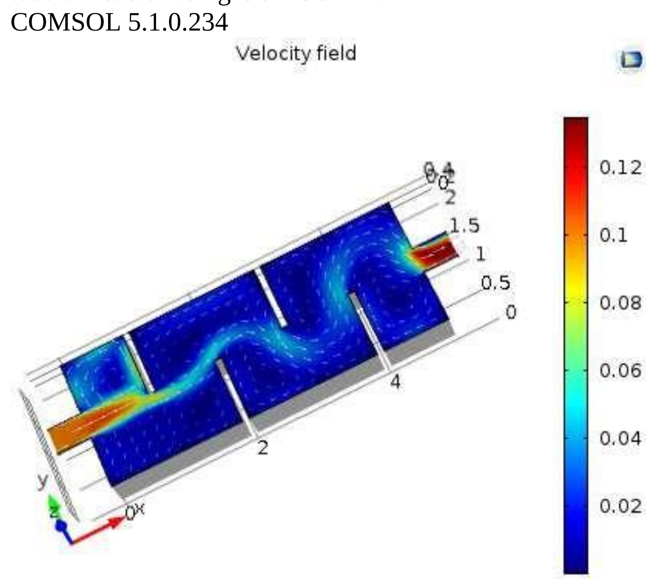

Figure 2: Velocity profile in plug flow reactor

tiphysics software. Author had selected laminar flow using Navier-stokes and species transport equation and compared their results with experimental data and found the average residence time 3.0 minutes.[28]

Agusto.et.al evaluated the pollution level by mathematical model using Finite Difference Method. Authors had showed the mathematical model for the concentration of Biological Oxy- gen Demand (B.O.D), Dissolve Oxygen (D.O.) and dissolved Organic Matter (D.O.M.) using generalised transport equation and have implemented Crank-Nicolson numerical scheme using Central Differece scheme in space and forward differecne scheme in time.[35]

Pochai.et.al showed the water pollution in stream using Finite Difference scheme. Authors had showed the dispersion of COD concentration using convection-diffusion equation in a stream by using central difference scheme.[34]

N.Pochai showed mathematical formulation for the linear and non linear flow in stream. He suggested finite difference scheme to model pollution level in sewage. He used advection- dispersion-reaction model equations in one dimensional for the same and hydrodynamic model for the velocity data in the stream.[34]

2.4 Reviews on Air pollution dispersion in CFD

Goissesau.et.al showed their work in dispersion of pollutants on the building surfaces and sur- rounding streets. They predicted the pollutant dispersion with RANS-$k - \varepsilon$ models and Large Eddy simulation (LES) model. Experimental validation carried out using wind tunnels and
found the better simulation results in LES model as compared with RANS models.[29]

Amorium.et al showed air pollutants exposure to the pedestrian and its effects on road side trees. Authors predicted the exposure of carbon monoxide (CO) to the atmosphere from the vehicular emission. CFD modelling has been carried out for this pollutant for the pedestrian to select the walkway for school. Wind flow simulations carried out using RANS $k - \varepsilon$ model[30]

Triscone.et.al predicted air pollution dispersion using CFD and presented their study for the nitrogen dioxide and particulate emission near lake front under clean city project. Authors performed experiments with wind tunnels and validated results using CFD[31].

Singh has presented dispersion of pollutants from vehicular emission using CFD. Air pollu- tions from the vehicular emissions entrapped by street canons and increase the concentration of pollutants over there. CFD analysis carried out using ANSYS CFX-12 code considering various test parameters like wind direction, wind speed, aspect ratio. Simulation carried out using standard, RNG and reliable $k - \varepsilon$ turbulence model[32].

Panagopoulos.et.al showed their study in dispersion of Volatile Organic Compounds (VOC), Carbon dioxide, Formaldehyde as indoor Air pollutants. Authors predicted air flow from kitchen with open access to living room ventilated by an exhaust hood in an apartment. Different lo- cations of cooker/oven and air inlets were chosen and simulations carried out using CFD code: PHOENICS[33].

Pochai has developed the mathematical model for smoke dispersion from the source. Author had used convection-diffusion equation in semi implicit finite difference scheme to measure the smoke concentration at different level distances.[34]

3. Concluding Remark

World's fluid related environmental issues can be easily addressed using computational fluid dynamics. Such computational methods can reduce the experimental time and cost. This paper showed the importance of the computational fluid dynamics in Environmental Engineering aspects. Environmental Engineering problems related to chemical and biological treatment, residence time measurement, measuring dosage of chemicals and impact and position of jet for proper mixing of chemicals. This also includes ultra-violet lights distribution for disinfection of water. CFD also helps in measuring the pollutant concentration at various distances in a tank or streams like COD concentration, BOD concentration etc. CFD not only helps in water treatment systems but it also works well with air pollution problems. Gases form the vehicular emission or stacks can be easily predicted at various heights using CFD.

References

[1] *Introduction of Computational Fluid dynamics*. Pearson, 2006.
[2] *Computational Fluid dynamics*. Narosa Publishing house, 2014.
[3] *Application of CFD in Environmental Engineering*, 2012.
[4] J. Laurent, R. W. Samstag, J. Ducoste, A. Griborio, I. Nopens, D. Batstone, J. Wicks,S. Sauders, and O. Potier, "A protocol for the use of computational fluid dynamics as a supportive tool for waste water treatment plant modelling," *IWA, Water Science and Technology*, 2014.

 ISBN: 978-93-90214-19-8

[5] N. Jaiklom, E. Bumrunhthaichaichan, and S. Wattananusorn, “Cfd simulation of turbulent jet mixing tank.”

[6] M. Irfan, B. Kailash, and G. Subramanya, “Cfd analysis of a single phase mixing of fluids without the aid of stirrers,” *International Research Journal of engineering and Technology (IRJET)*, December 2015.

[7] M. Marek, T. Stoesser, J. Roberts, V. Weitbrecht, and G. Jirka, “Cfd modelling of turbu- lent jet mixing in a water storage tank.”

[8] D. Rajavathsavai, A. Khapre, and B. Munshi, “Study of mixing behaviour of cstr using cfd,” *Brazilian Journal of Chemical Engineering*, vol. 31, pp. 119–129, march 2014.

[9] J. Aubin and C. Xuereb, “Design of multiple impeller stirred tanks for the mixing of highly viscous fluids using cfd,” *Chem.Eng.Sci*, no. 2913-2920, 2006.

[10] A. Ochieng, M. Onyango, and K. Kiriamiti, “Experimental measurement and computa- tional fluid dynamics simulation of mixing in a stirred tank: A review,” *South African Journal of Science*, no. November/December, 2009.

[11] A. Paravareh, M. Rahimi, and A. Alsairafi, “Experimental and cfd studies on the effect of the jet position on mixing performance,” *Iranian Journal of chemical Engineering*, vol. 6, 2009.

[12] A. Farbod, J. Moghaddas, and M. Shokrgozar, “Cfd simulation and experimental inves- tigation of a jet mixer: Effect of flow rate and jet angle on mixing time using the rsm model,” *International Regional Chemical and Petroleum Engineering*, 2010.

[13] S. Zhang, D.Muller, H.Garcia, and G.Wonzy, “Cfd simulations of the fluid hydrodynamics in a continuous stirred-tank reactor,” *Chemical Engineering Transaction*, vol. 32, 2013.

[14] A. Ochieng and M. Onyango, “Cfd simulations of solids suspension in a stirred tank: A review.”

[15] K. Sendilkumar, P. Kalaichelvi, M. Perumalsamy, A. Arunagiri, and T. Raja, “Computa- tional fluid dynamic analysis of mixing characteristics inside a jet mixer for newtonian and non newtonian fluids,” *Processing’s of the World Congress on Engineering and Computer Science*, 2007.

[16] B. Choi, B. Wan, S. Philyaw, K. Dhanasekharan, and T. Ring, “Residence time distribution in a stirred tank-comparison of cfd predictions with experiments,” *industrial & Engineering Chemistry Research*, 2003.

[17] J. Bridgeman, B. Jefferson, and S. Parsons, “Computational fluid dynamics modelling of flocculation in water treatment: A review,” *journal of Engineering Applications of Computational Fluid Mechanics*, vol. 3, no. 2, pp. 220–241, 2009.

[18] J. Peres and A. Vianna, “Simulating phenol oxidation in an annular photo reactor using computational fluid dynamics.”

[19] M. Moghaddami and M. Raisee, “Performance and energy consumption analysis of uv-h2o2 photo reactor using computational fluid dynamics,” *International Journal of Environmen- tal Science and Development*, vol. 3, no. 4, august 2012.

[20] R. Saha, M. Ray, and C. Zhang, “Scalability analysis of an open channel uv waste water disinfection reactor using cfd simulations.”

[21] E. Kenny, S. Couperthwaite, and G. Millar, “Cfd fluid flow modelling in amd lime neu- tralization tank: Identifying the flow characteristics that facilitate scale formation,” *11th International Conference on CFD in the minerals and process industries*, December 2015.

[22] C. Harris, D. Roekaerts, and F. Rosendal, “Computational fluid dynamics for chemical reactor engineering,” *Chemical Engineering Science*, vol. 51, pp. 1569–1594, 1996.

[23] N. Pochai, S.Tangmanee, L.Crane, and J.Miller, “A mathematical model of water pollution control using the finite element method,” *Wiley*, 2006.

[24] B.Korbahti, “Finite element modelling of continuous flow tubular electrochemical reactor for industrial and domestic waste water treatment,” *Journal of the Electrochemical Society*, 2014.

[25] N.Wright and D.Hargreaves, "The use of cfd in the evaluation of uv treatment systems," *Journal of Hydroinformatics*, 2001.
[26] *On a particle tracking technique to predict disinfection in drinking water treatment systems*, 2010.
[27] *Multiphysics Modelling of Calcium Carbonate Trasportation in UV Disinfection in Water Treatment*, 2009.
[28] *Residence Time distribution for Tubular Reactors*, 2014.
[29] P. Gousseau, B. Blocken, T. Stathopoulos, and G.Heijst, "Cfd simulation of near-field pollutant dispersion on a high-resolution grid: a case study by les and rans for a building group in downtown montreal," *Atmospheric Environment*, pp. 428–438, 2011.
[30] J. Amorium, J. Valente, P. Casao, C. Pimentel, A. Miranda, and C. Borrego, "Pedestrian exposure to air pollution in cities: modelling the effect of roadside trees."
[31] G. Triscone, N. Addennadher, C. Balistreri, O. Donze, D. Greco, P. Haas, H. Pekoz, T.Nour, P. Munier, P. Pontelandolfo, R. Putzu, J. Richard, and H. Sthioul, "Computa- tional fluid dynamics as a tool to predict the air pollution dispersion in a neighbourhood- a research project to improve the quality of life in cities," *Smart city Expo World Congress*, 2014.
[32] A. Singh, "Vehicular pollutants dispersion modelling analysis in street canyons using com- putational fluid dynamics (cfd)," *International Journal of Engineering Research & Tech- nology(IJERT)*, vol. 2, June 2013.
[33] I. Panagopoulos, A. Karayannis, and P. Kassomenos, "A cfd simulation study of voc and formaldehyde indoor air pollution dispersion in an apartment as part of an indoor pollution management plan," *Aerosol and air quality Research*, 2011.
[34] N.Pochai, "A finite element solution of the mathematical model for smoke dispersion from two sources," *International journal of Mathematics and Computational Science*, 2011.
[35] F. Agusto and O.Bamigbola, "Numerical treatment of the mathematical models for water pollution," *Journal of Mathematics and statistics*, 2007..[51-54]

 ISBN: 978-93-90214-19-8

Behavior of Stiffened Steeel Plates under In-Plane Load with Lateral Pressure for Different Plate Slenderness Ratio

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Abstract - The present work provides a non-linear elasto-plastic FEM analysis using ABAQUS package of the collapse behavior of stiffened steel plates as experimental investigation available in literature. The plates are subjected to combinations of uniform in-plane loading and lateral pressure with twelve nos. of stiffened plates with two plate slenderness ratios, 76 and 100 with actual initial geometric imperfection measured along with strains, axial shortening and lateral deflections of the test specimens. The FEM consist a surface model of 8-noded doubly curved thin shell, reduced integration, using five degrees of freedom per node to avoid any ill-conditioning in the analysis and extended to slenderness ratio of range 30 - 100. The FEM results were compared with experimental available in the literature. Boundary conditions were modeled as close to the actual experimental conditions as restrained. With imperfections, FEM result agreed well with the experimental results for ultimate loads but there were some differences found for deflection at ultimate loads.

Keywords: stiffened plates, lateral pressure, in-plane loading, plate slenderness ratios, FEM analysis

Introduction

Stiffened steel plates are used extensively for ship decks and hulls, components of box girder, bridge decks and offshore and aerospace structures. Stiffened plates in marine and offshore structures are usually subjected to the combined action of lateral and in-plane loads. Stiffeners may be provided in longitudinal or transverse directions or both directions. The advantage of stiffening lies in achieving an economical and lightweight design. The presence of stiffeners increases the ultimate load capacity of the plate significantly but it makes the design more complicated due to involvement of more parameters.

Materials and Dimensions:

a-The plates were divided into two groups, group A and group B, according to the slenderness ratio, which is equal to 100(b/t=290/2.9=100) and 76(b/t=220/2.9=76) for groups A and B respectively.
b- Plate dimensions for both groups as the figures (1), (2).

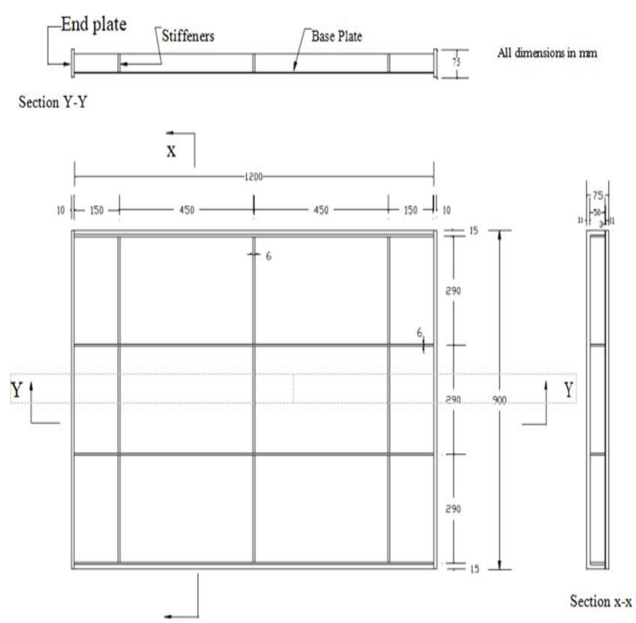

Figure (1) Dimensions of Series A Specimen in mm

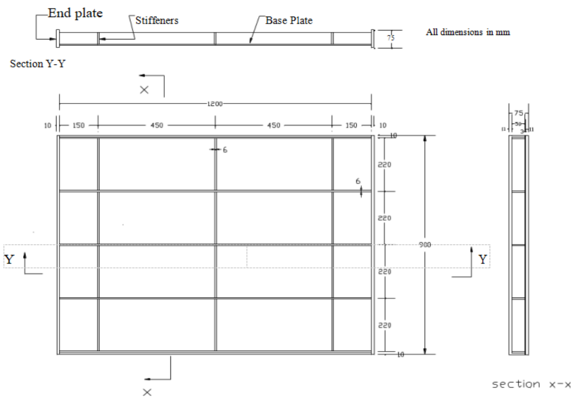

Figure (2) Dimensions of Series B Specimen in mm

c-Material Properties for Base Plate and Stiffeners (table(1)):

Table (1): Material specifications for plate and stiffeners.

	Sample no.				
	1	2	3	4	Average
Base plate					
Yield strength (N/mm^2)	343	368	335	341	347
Young's modulus E (GPa)	204	190	197	172	191
Stiffeners					
Yield strength (N/mm^2)	333	335	327	337	333
Young's modulus E (GPa)	185	191	199	199	194

Experiment (Shanmugam et al, 2014):
A check rig during which stiffened plates are often tested beneath each in-plane load and lateral pressure was utilized in this project. A sectional view of the check rig is shown in Figure three. An extremely stiff thrust beam forms a part of the axial loading frame to transfer the axial load utterly from hydraulic jacks to the specimen. A bag with an overall dimension of 914- millimetre x 914 millimetres was wont to apply lateral pressure to the specimen.

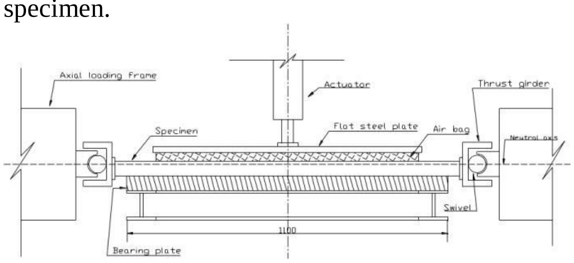

Figure (3) Sectional View of the Experimental Setup

The axial load and lateral pressure were applied at the same time with axial load reaching the pre-determined level a lot quicker than lateral pressure. With the axial load maintained constant at that level, the specimen was tested to failure by bit by bit increasing the lateral pressure. Readings of strain gauges and displacement transducers were recorded for every increment of load in addition to every occasion interval of twenty seconds. Pressure within the bag was recorded manually at the designated load level. the final word lateral load at failure might be determined from the load-deflection curve of pc output. For each series, all the specimens were tested to failure beneath completely different combos of loadings. A1 and B1 were tested to failure beneath lateral pressure solely. A6 and B6 were tested beneath axial load solely. the remainder of the specimens were tested to failure beneath completely different combined action of axial load and lateral pressure.

Table (2): Shows the appled axial and lateral load from the experiments (Shanmugam et al, 2014)

Series	Specimen	Axial load P (kN)	Lateral load Q_u (kN)
			Experimental
A	A1	0	246.3
	A2	170	201.6
	A3	300	147.4
	A4	400	112.8
	A5	500	75.1
	A6 (axial load only)	P_{exp}=712.0 kN	
B	B1	0	250.9
	B2	200	203.8
	B3	400	145.7
	B4	520	95.4
	B5	630	93.3
	B6 (axial load only)	P_{exp}=785.4 kN	

FEM analysis:
By exploitation ABAQUS for analysis, the weather area unit of sort S8R5 in ABAQUS nomenclature. The S8R5 component is chosen as a result of its strong eight-node commonplace ABAQUS plate-bending component that enables for changes within the thickness similarly to finite membrane strain. Material non-

ISBN: 978-93-90214-19-8

linearity may be accounted for by the applicable choice of fabric model in ABAQUS. The classical metal malleability model is acceptable for general collapse analysis. The classical metal malleability models in ABAQUS use commonplace von Mises yield surface models with the associated plastic flow. This yield surface assumes that the yield of the metal is freelance of the equivalent pressure stress. Associated plastic flow suggests that, because the material is yielding, the inflexible deformation rate is within the direction of traditional to the yield surface. within the gift study, the non-linear elastoplastic model was hand-picked and ideal malleability was used. At the analysis stage, a non-linear analysis was performed to account for material non-linearity. Boundary conditions area unit is sculpturesque as near to the particular experimental conditions as doable so that the numerical results may be wont to validate the responsibleness of the FEM investigation. Stiffened plates were sculpturesque as merely supported on the sting stiffeners. All nodes on the boundaries were restrained within the vertical direction and also the nodes on one in every one of the transversal edges were restrained within the longitudinal direction to simulate the particular boundary conditions within the experiment. 2 corner nodes on one in every one of the longitudinal edges were restrained within the model to stop the free movement of stiffened plates on the transversal direction.

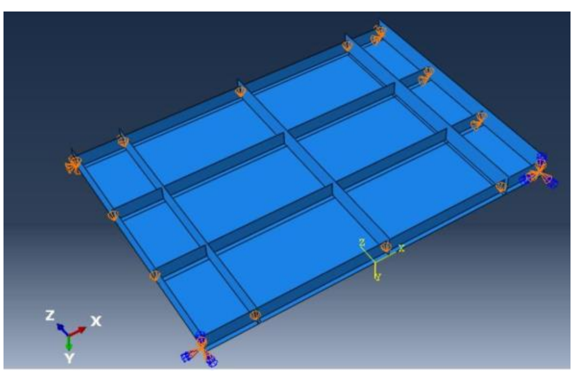

Figure (4) Boundary conditions of Stiffened Plate

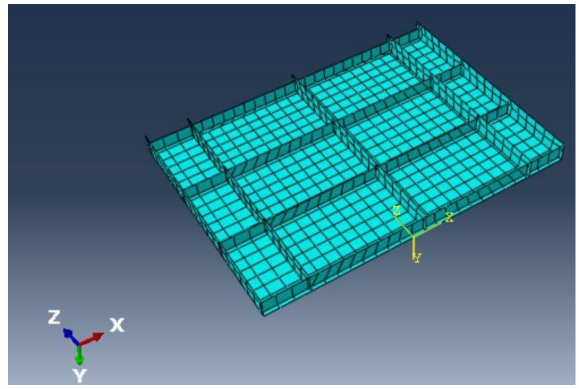

Figure (5) Typical Mesh of Stiffened Plate

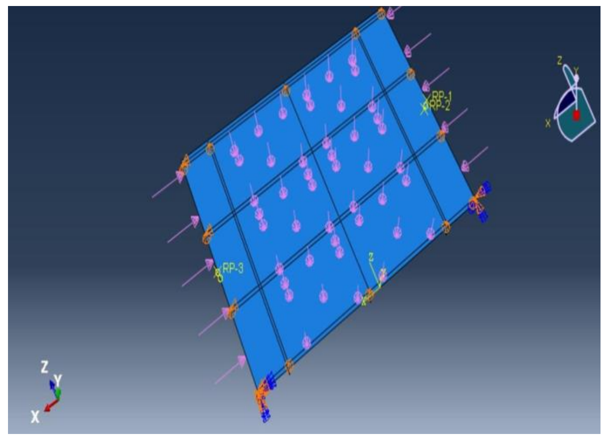

Figure (6) Boundary conditions and loads of Stiffened Plate

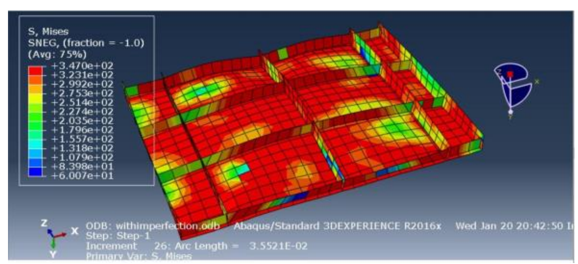

Figure (7) Failure of Stiffened Plate in ABAQUS

ISBN: 978-93-90214-19-8

Figure (7) Failure of Stiffened Plate in experiment

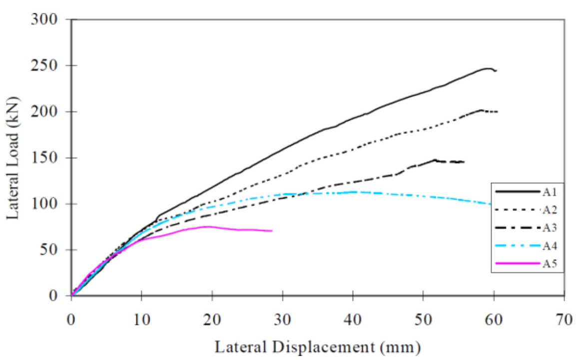

Figure 8 Lateral Load vs Displacement Curves for Series A

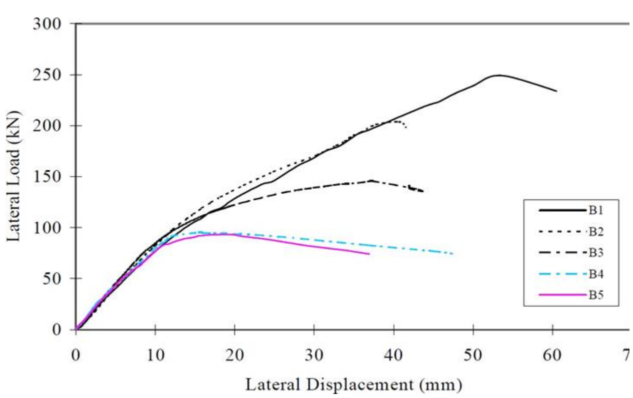

Figure 9 Lateral Load vs Displacement Curves for Series B

Table 3 Comparison of Experimental Results and ABAQUS Results

Specimen No.	Axial Load P (kN)	Lateral Load Qu (kN)		Q abq/ Q exp
		Exp.	ABAQUS	
A1	0	246.3	252.1	1.02
A2	170	201.6	183	0.91
A3	300	147.4	135.2	0.92
A4	400	112.8	105.8	0.94
A5	500	75.1	74.7	0.99
B1	0	250.9	262.6	1.05
B2	200	203.8	204.8	1
B3	400	145.7	141.2	0.97
B4	520	95.4	107.7	1.13
B5	630	93.3	96.4	1.03

Specimens under axial load only				
Specimen No.	Lateral Load P (kN)	Axial Load Pu (kN)		P abq/ Pexp
		Exp.	ABAQUS	
A6	0	712	769	1.08
B6	0	785.4	819.5	1.04

-The specimens tested within the current study were analyzed by ABAQUS finite component package was compared to experimental results. within the ABAQUS analyses, models with each nominal state and actual measured state were studied. Table three shows the comparison of experimental results with the finite component results with nominal state. it's found that ABAQUS results agree well with the experimental results.

After simulation study, the parameter of slenderness magnitude relation of plates b/tp varied per the thickness of base plate tp. the size of stiffened plates square measure summarized in Table 4:

Table 4 Dimensions of Stiffened Plates for Parametric Studies

Specimen No.	b/tp	tp (mm)	Longitudinal stiffeners		Transverse stiffeners	
			Spacing (mm)	Size (mm x mm x mm x mm)	Spacing (mm)	Size (mm x mm x mm x mm)
SP30	30	20				
SP40	40	15				
SP50	50	12				
SP60	60	10				
SP70	70	8.57	600	150 x 10 x 80 x 15	1500	250 x 10 x 120 x 18
SP80	80	7.5				
SP90	90	6.67				
SP100	100	6				

Table 5 Summary of Parametric Study Results

Specimen No.	b/tp	P (kN) ABAQUS	tp (mm)
SP30	30	20775	20
SP40	40	15289	15
SP50	50	12595	12
SP60	60	11056	10
SP70	70	9478	8.57
SP80	80	8067	7.5
SP90	90	7283	6.67
SP100	100	6669	6

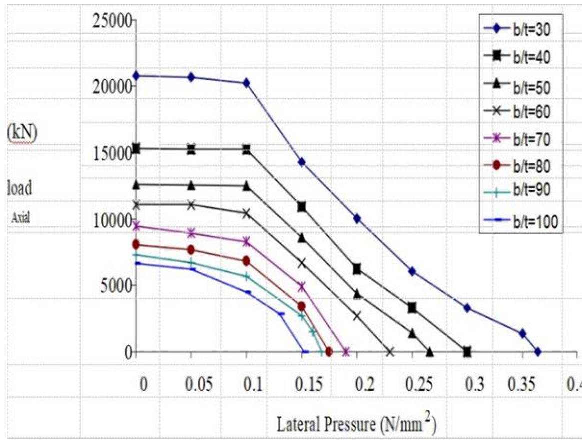

Figure 10 Interaction Curves for Stiffened Plates Considered in Parametric Studies

Results and Discussion

Increasing b/tp typically leads to a decrease in the plate strength and a discount in column strength of the stiffener-plate assembly. Figure ten shows the final word many stiffened plates beneath completely different mixtures of axial load and lateral pressure for plate slenderness starting from thirty to one hundred. The curves show that the rise in b/tp quantitative relation leads to a decrease of final load chemical element for all cases, notwithstanding the intensity of the lateral pressure. The reduction of the final load is additionally vital for b/tp = thirty to fifty. For b/tp quantitative relation larger than sixty, the reduction of strength because of modification of b/tp isn't thus distinguished. so for a specific filler space and l/b quantitative relation, b/tp quantitative relation could be an essential parameter, that affects the loss of final strength of the stiffened plate. From table five, it's found that the final word load to squash load quantitative relation is higher with lower quantitative relation of b/tp. The stiffened plate is simpler to resist compressive force with low plate slenderness quantitative relation since the section is thickset. For stiffened plates with high b/tp quantitative relation, the result of native buckling of the base plate is additionally vital. native buckling reduces the affective dimension of the stiffened panel. This reduces the final word axial load capability. In follow, b/tp quantitative relation between forty to seventy is generally adopted within the style of stiffened plates.

CONCLUSION

Plate slenderness ratios (b/tp) have an important influence on the last word load of stiffened plates subjected to each in-plane load and lateral pressure. An increase of plate slenderness quantitative relation leads to a decrease of final load capability of the stiffened plate.

ACKNOWLEDGMENT

The author would like to thank Kalinga Institute of Industrial Technology (KIIT) and express my sincere gratitude Prof (MS) Sushree Sangita Panda in School of Civil Engineering for her guidance and support for taking up this research.

REFERENCES

Alinia M.M and Dastfan M (2007). "Cyclic behavior, deformability and rigidity of stiffened steel shear panels". Journal of Constructional Steel analysis sixty three 554–563.

Alinia M.M, Gheitasi A and Erfani S (2009). "Plastic shear buckling of unstiffened heavyset plates". Journal of Constructional Steel analysis sixty five 1631–1643.

Ghavami K and Khedmati M.R. (2006) "Numerical and experimental investigations on the compression behavior of stiffened plates". Journal of Constructional Steel analysis sixty two 1087– 1100.

Saad-Eldeen S, Garbatov Y and Guedes Soares C. (2015) "Stress–strain analysis of crumpled rectangular plates subjected to uni-axial compressive loading". Engineering Structures ninety nine 78–91.

Shanmugam N.E, ZhuDongqi, Choo Y.S and Arockiaswamy M. (2014)"Experimental studies on stiffened plates below in-plane load and lateral pressure" ,Thin-Walled Structures eighty, 22– 31.

Suneel Kumar M, Alagusundaramoorthy P, and Sundaravadivelu R. (2009) "Ultimate strength of stiffened plates with a sq. gap below axial and out-of-plane loads". Engineering Structures thirty one 25682579.

Tata Steel, BCSA and also the SCI, (2005). "Stiffeners", accessible at: http://www.steelconstruction.info/Stiffeners.

Review on Effect of Floating Columns on Buildings Subjected to Seismic Forces

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Abstract - In recent trends, due to shortage of spaces, buildings in urban cities are required to have column free spaces, population and for functional requirements. Architectural features of buildings which gives poor response to earthquake should be avoided or must be minimized. Floating Column is one of such element. It is used to accommodate parking or reception lobbies in the first storey but such elements are Highly Undesirable in earthquake prone zones. This Review highlights the various literatures that have been studied performance of floating column building and compared with normal building under seismic loads.This Study also focuses on the areas that can be focused; so as to achieve desirable results by using floating column in Buildings

Keywords: Floating Column, Seismic Analysis,SAP2000, ETabs, STAAD Pro, FRP, CFRP, Bracings

Introduction

In some cases, Column which floats on beams at an intermediate storey does not go to foundation. Their load transfer path is obstructed and hence they are called as the floating columns. [6] Earthquake load depends on different parameters like properties of soil, type of construction, their seismic zones and geometry of plan. magnitude of Lateral load depends upon the intensity of peak ground acceleration of that seismic zone. [31] The Horizontal member transfers the load to other columns below it. Floating columns are used to acquire available open space in and above the ground floor, where transfer girders are used. These open spaces are required for commercial purpose like assembly hall or parking purpose etc. [18]

A Column is that vertical Compression member which transfers the load of superstructure to undelying foundation and then to the ground. Lower end of floating column is rested on horizontal beam. Hence the load coming from adjacent beam is transferred to the columns and then to foundation [21]

In seismically active zones, all transfer girders should be designed properly because The load coming from floating column act as a concentrated load on them. During the seismic analysis, the floating column is assumed to be pinned at the base and hence it acts as a concentrated load on the transfer girder. [16]

LITERATURE REVIEW

1. Maison Bruce F. and Neuss Carl F

In this study, they had analyzed a high-rise Building having forty four story steel frame. He has studied the effect of various modeling methods on the assumed dynamic properties and also computed values of seismic responses. Building's actual properties were determined from experimental testing and the assumed dynamic

properties were compared. They used response spectrum and equivalent static load methods for computing seismic response behaviors. [1]

2. Maison Bruce F. and Ventura Carlos E

Here they have computed response behaviors and dynamic properties of Thirteen-Story Building. During two actual earthquakes, Actual values were determined from computed motions in the building. The Result of their study was compared with the actual values of the ground motion and it is shown that analytical model can predict the true Dynamic Properties of the structure [2]

3. Arlekar Jaswant N, Jain Sudhir K. and

Murty C.V.R

They suggested that such elements are undesirable in buildings built in seismically active zones. They have given verification in various sites of the past earthquakes having strong shakings. In the analysis of the building.They also focused on the importance of clear recognizing the nine presence of the open first storey. This involves balancing of stiffness of the open first storey and the storey above, were proposed to reduce the irregularity
introduced by the open first storey. [3]

4. Andrea Prota, Antonio Nanni, Gaetano Manfredi, and Edoardo Cosenza

They have done testing on 11 under designed specimen. By this Experiment they have done the seismic up gradation of RC Beam Column Connections using fiber-reinforced polymer (FRP) composites. The results were discussed in terms of durability and strength of structure. In this study, they explained the fact that in behavior of the under designed frame, the lower bound leads to the failure of column. The columns can be upgraded by providing them confinement or greater flexural reinforcement. Like this failure will occur at joint And hence in such cases Beam Column Connections should be designed with FRP composites [4]

5. Awkar J. C. and Lui E.M

Here they studied the earthquake excitation response of multi-story frames using software model. In this analyses,The model includes geometrical and material nonlinearities. It also contains connection flexibility. At the end of study, they concluded that due to flexibility of connection there is increase in inter-storey drifts of the upper storey. On other hand it also reduces base overturning moments and base shears for multi- story frames. [5]

6. Balsamoa A, Colombo A, Manfredi G,
Negro P & Prota P
They have performed pseudo dynamic tests on an RC structure repaired with CFRP laminates. After seismic action, the structural properties of columns and joints were detoriated.Hence to recover those structural properties, The CRPF repair was done. Depending upon the mechanism controlling each component; the repairing was distinguished by a selecting of different fiber textures. The required principles in design of CRPF repair are mentioned in this study and there experimental test outputs are compared.Comparision between Original and repaired structure were discussed. The Results also represents the database for developing the design criteria for Seismic Repair of RCC structure using composite material. [6]

7. Vassilopoulos A.A and Beskos D.E
They performed seismic design methodology for plane steel frames using advanced methods.This design experiment includes finite-element method of analysis. Factors which they took into account were imperfections of member and frame, geometrical and material nonlinearities. Using accelerograms, the inelastic dynamic method were employed. For better compatibility,this was taken from the real earthquakes scale withelastic design spectrum of Eurocode 8. Initially member sections were assumed and it continues with the, damage, drifts, the ultimate and serviceable limit state, and plastic rotation, plastic hinges pattern checks for the damages. The design procedure ends with adjustment of sizes of member. All time history analysis were performed using natural seismic records. Objectives of performance at each section of frame are checked for the the ultimate limit state (ULS), damage limit state (DLS) and serviceability limit state (SLS). Thus, a performance based design is obtained. [7]

8. Bardakis V.G., Dritsos S.E.
They have evaluated the European and American procedural assumptions for the analyzing seismic response of existing structure using pushover analysis. The GRECO and FEMA procedures were used in order to study a four storeyed framed structure. [8]
9. Mortezaei A., Ronagh H.R., Kheyroddin A.
In this study it is shown that motion in ground surface near the area of a rupturing fault varies from ordinary motion; because they contains large amount of energy. Hence these pulses can damage to structures during an earthquake with natural periods near to pulse. Hence structure requires strengthening for there well performance .In this study; Due to, low life cycle costs , relatively easy and quick

installation and zero maintenance requirement; Author have suggested Fiber Reinforced Polymers to be a good alternative to differentiate the response of actual RCC structure to near fault ground motions. The demonstration shown that strengthening using FRP was effective in reduction of drift demands for structures with greater range of natural periods. [9]

10. Williams Ryan J., Gardoni Paolo, Bracci Joseph M

They have used framework details to study the economic benefit of a given retrofit procedure. An analysis was done to determine range of parameters which affects the usage of seismic retrofitting of structures. case study was done in San Francisco and Memphis using an adequate retrofitting. The results showed that , the seismic retrofit of an existing building in San Francisco was more financially viable as compared to Memphis. [10]

11. B.M. Brodericka, , A.Y. Elghazoulib, J. Goggins

In this study nonlinear static (pushover) and transient time-history analyses were considered. Two tubular steel members imaparted the lateral resistance of test frames .The cross-section of braces were varied among tests for analyzing effect of slenderness, resistance, ductility and stiffness shown by given frame under earthquake loadings. Response simulations were compared with the result obtained after experiment. Brace strengths and Properties of Elastic test frame were established in static tensile tests and low-level shake table tests respectively. Using this, model input data

were determined. At the end, the analytical results similar to experimental results with respect to brace tension forces and frame base shear. [11]

12. M.A. Shayanfar , A. Kheyroddii and M. S. Mirza

In this paper, Author have investigated non-linear finite element analysis of concrete structures .they have studied effect of size of finite element. The effect of size of element on various behavior aspects of RC structures including the load-strain characteristics,load- displacement, ultimate load and pattern of crack were discussed .Comparison of experimental data was also done. Toterminate the dependency of calculated results on finite element size; an easy procedure for calculation of ultimate tensile strain of concrete was created and converted into non-linear finite element formulation. The given model was nearly similar to experimental results. Hence it was concluded that by providing coarse finite element meshes the new model can be utilized effectively [12]

13. Garcia Reyes, Hajirasouliha Iman, Pilakoutas Kypros

Here Author have tested a two-storey RCC building with poor beam-column joint using shake table. Initially tests damaged the structure, hence carbon fibre reinforced material (CFRPs) were used for strengthening and re- tested. Here author have investigated strengthening method for improving the behavior of this building subjected to seismic forces. To calibrate the analytical models, data from shake table tests were used. For simulation of weak beam-column joints; models of bond strength degradation under the cyclic load were considered. These models were used to check the efficiency of CFRP .At the end, The CFRP strengthening has increased the strenght of beam-column joints. By using CFRP ,the damage in building was reduced by 65% as compared to real structure. [13]

14. Niroomandia A , Maherib A , Maheric Mahmoud R , Mahini S.S

They have rehabilitated an eight-storey building which was previously strengthened with a steel braces whose web was bonded using CFRP. Comparison was done between seismic performances of both above methods. At the end it was observed that both retrofitting methods had abilities for increment of over strength factor and ductility reduction factor. The steel braces of the RCC frame can be beneficial if a considerable the resisting capacity of lateral load and increase in stiffness is required. Similarly, FRP retrofitting at joints can be done in addition with columns and beams to achieve the desired results. [14]

15. Nanni. A., and Faza, S.

In this paper, Author presented reports on design guidelines and their present experience of using of FRP composites for RCC structures. They analyzed that FRP bars should be used to replace conventional steel rebars for prevention of reinforcement

ISBN: 978-93-90214-19-8

corrosion. Main purpose of this study was to experiment with steel- reinforced concrete practice by including the modifications by using physic mechanical characteristics of FRP[15]

16. Vignesh Kini K. , Rajeeva S. V.

In this Study, Author has done Response Spectrum Analysis of RC Steel Composite Building with Floating Columns.For analysis of Non Linear Behaviour of structural members was carried out.These Analysis has been carried out using CSI ETABS 2016 software. Author has compared parameters like Maximum values of Bending Moment, Shear Force and Deflection of the transfer Beam. They have Modelled Two types of Structure in ETABS ,1st Model was G+20 RC building with floating columns placed at middle of penultimate bay. 2nd Model was steel concrete composite multistorey building with floating columns at the same placement as previous. From the this study, it was seen that transfer beams of Model 2 had more moment carrying capacity as compared to Model 1. It was also analyzed that composite beams had less shear force than RC transfer beams. From the analysis, the deflection of steel- concrete composite beams with Floating Column was less in response spectrum and construction sequence analysis. [16]

17. Kishalay Maitra, N. H. M Kamrujjaman Serker

In this Research, behavior of multi storyed building has been analyzed with floating columns. The Building was subjected to Seismic forces. Author have considered different types of cases, varying with sizes of beams, columns and their orientation. Method of Analysis used was Equivalent Static Analysis , Response Spectrum Analysis and Modal Analysis. The Result Showed 56.96%

increment in storey displacement in building with floating column as compared to conventional building. Torsional Irregularity was found out by unsymmetrical placement of Column. Hence it’s is concluded that Torsional Irregularity is independent of floating column number or ground floor column size .It is depending upon location of Floating column. Present study shows that Storey Stiffness in floating column building can be increased by increasing ground floor column sizes .In seismic prone areas, Column sizes should be increased so as to avoid soft story effect. [17]

18. Trupanshu Patel

In this Paper, Author has done the comparison of various models with each other according to the position of floating columns, storey wise comparison, and comparison between models with and without increment of live load, and comparative study for building with and without effect of infill. The Model have been analyzed using SAP 2000 and Results were obtained in terms of vertical and horizontal Displacements. In this research, it is observed that Corner Position of Floating Columns should be avoided so as to have minimum Displacement. It is preferred to shift floating columns from corner to center of stiffness of floors to achieve higher Decrement in Vertical Displacement. Analytical Result of this study shows that after infill provisions,horizontal and vertical displacement reduces by 182.26% (max) and 140.03% (max) respectively.[18]

19. Mohammed Umeruddin , Dr. S Sunil Pratap Reddy , Bollaboina Naresh

In this Study Author have framed a G+10 Building having floating columns at various locations. The building has been modelled in STAAD Pro Software using Equivalent Static Method. After Analyzing the Structure Author has concluded that probability of failure of RCC building with floating columns located at outer boundary along two Longer Sides is more than floating columns located along two Shorter Sides. Analytically it is derived that Column shears values changing depends upon position and orientation of column. [19]

20. Mohasinkhan N. Bargir , Ajim G. Mujawar

Here Author have Modelled a G+10 structure in Different Cases by changing Floating Column’sPlacement and orientation as mentioned in the literature they have mentioned. But the Special type of study that has been carried out in this research is the model of Same Building with Floating Columns placed at corners with Symmetrical Triangular Plates placed on each Sides (i.e. Model-F).After Analyzing first rest of the other models, it was observed that results obtained in the form of displacement and base shear were similar as mentioned in there Literature. In second Case, Base shear is less when floating column is added as that of normal building .But after adding triangular plate at the beam column joint, there is increment in base shear It is also observed that the storey Drift and displacements have also been reduced as compared to normal Floating Column Buildings. By provision of triangular plates, base shear is increased. [20]

21. Susanta Banerjee , Sanjaya Kumar Patro

In this Research analysis was done by nonlinear analysis program IDARC2D.for evaluation of damage indices was done using modified Park & Ang model. During Analysis all buildings were considered as ordinary moment resisting frames.In this study Author has Introduced Compression struts as an Infill walls. These struts were placed Crossed as "X" between two adjacent Floating Column. After the study it is observed that, top floor displacement was higher in case of Floating Columns only. Whereas the top floor displacement was reduced by provision of infill walls as mentioned above. Storey drift was also reduced due to presence of infill walls between floating columns. Infill wall increases stiffness of Floating Column Building which leads to increment in Base Shear. Overall structural damage was increased due to infill wall effect.According to study of Damage Index ,top floors are free from damage and cracks. During earthquake, plastic hinge were formed in presence of infill wall. [21]

22. Ms.Waykule S.B , Prof. Kadam.S.S

In this Research building has been analyzed for different cases by changing the location of floating Columns floor wise. The Structural response of model has been carried out using software SAP2000V17. After studying of all literatures it was concluded that more study is required for building with floating column as safety point of view during earthquake. All literature review in this study shows better result for normal building as compared to floating column building. [22]

23. Vinay Agrawal , Suyash Garg

In this Paper ,researchers have analyzed two separate models ,the equivalent static analysis and response spectrum analysis. Different measures has been examined such as Bracings and shear walls, Strengthening of column in ground storey and their different alterations were examined. This study shows that load transfer from floating columns becomes less when Chevron Bracings were placed just below them. This reduced the shear force on beam upon which floating column is rested. [23]

24. Mr. Gaurav Pandey, Mr. Sagar Jamle

This Research has been carried out on G+14 Building Using STADD Pro software. Various locations of floating columns has been analyzed and their values of displacement, Shear Force, Bending Moment has been Compared. Hence, It is observed that there are specifically four locations and arrangements where the results were best optimized. These locations were such that Floating columns were placed at all four corners in G+9 and G+12th Floor .Similarly they were placed ay center of outer periphery in G+9 and G+12 th Floor . Comparing the Story drift for these cases in both longitudinal and transverse direction, were observed as most efficient. On analyzing shear force and bending moment values, Case in which floating column at center of outer periphery all around in G+9 only found to be optimum for both X & Z direction among all cases. [24]

25. Hardik Bhensdadia , Siddharth Shah

Here Push over analysis was carried out. In this analysis, design capacity (displacement) is carried out up to failure. The present study compares the behavior of a building with floating column complexities differs with normal floating column. The locations of floating column are also varied to determine its optimum position. By placing Floating Column at the edge and middle displacement values are increased.Whereas the displacement is less at lower zones and it increases for higher zones. [25]

26. Sreekanth Gandla Nanabala , Pradeep Kumar Ramancharla , Arunakanthi

In this study G+5 Storey building has been analyzed with and without floating column using SAP2000 Software. Here Author have applied the intensities of the previous earthquakes and studied the variations.Later Displacement time history values were compared. Objective was to check safety in seismically active areas and also to find economic aspects of floating column building.After research it is observed that Floating column building is unsafe and uneconomical to that of a normal building because Building with Floating column has approx 41% more rebar steel and concrete quantity as compared to normal building. [26]

27. Sabari S , Mr.Praveen J.V

Here Author have carried out FEM analysis to study the responses of the building under various earthquake excitation having different frequency content.PGA and time duration factor constant. The time history of roof displacement, inter storey drift, column axial force, base shear were obtained for both buildings. The dynamic analysis of frame was done by varying column size dimension.It is concluded that by increasing the column size ,the displacement and inter storey drift values can be reduced. [27]

28. Ganesh Kumbhar, Anirudhha Banhatti

In this Research analysis was done in ETABS.Lateral stiffness and strengthening was examined by lateral bracings, shear walls, increasing the column size. These were proposed to reduce the stiffness irregularity and discontinuity in the load path incorporated.It was observed that shear wall retrofit was suitable for retrofitting of soft story.It will also minimizes the displacement structure. [28]

29. Israa H. Nayel, Shereen Q. Abdulridha, Zahraa M. Kadhum

In this Paper Author have analyzed the building with floating columns and effect of different placement of shear wall has been analyzed. The first model was taken without shear wall.Others three models included shear wall at different location of the building to study the best location.The analysis was done by using the software ETABS-2015. The results represented that the base shear increased in case of core center shear wall in building when compared with another models which were considered in the present study. [29]

30. Isha Rohilla,S.M. Gupta , Babita Saini

In this paper, the critical position of floating column in vertically irregular buildings was discussed. Effect of change of sizes of beams and columns was also observed.The storey displacement, storey shear, and storey drift has been used to evaluate the results obtained. [30]

METHODOLOGY

The main objectives of the proposed work are:

1. To compare the modal response such as Mode shapes, Time period, Frequency of all the models. [22]
2. To compare the Storey drift, Base shear, Storey displacement and maximum displacement of each storey. [22]

The general software STAAD Pro V8i will be used for the Analyzing. Inthis research will be analyzing the structure with following steps:

1. Modelling of Building

A G+10 RC Structure will be modelled in the software. Various cases of structure will be modelled in order to analyze various placement and orientation of floating column. [20]

Shear Wall will also be placed as per previous researches
[23], which gives better results

In Some Cases Bracings will also introduced to study behavior of Structure.

2. Building Plan and Dimensions

A symmetrical Building will be taken for analysis so as to avoid torsional irregularities [17]. Different Sizes of Column and Beams will be taken to study effect of increased dimension. [12]

3. Loading Information

Various Loading conditions will be imposed on the structure along with seismic forces so as to study earthquake Analysis of the structure. [19]

4. Analysis based on Results

RESULTS AND DISCUSSIONS:

From Various Studies it is seen that floating column without any additional retrofitting is unsafe in Earthquake zones.Hence we can opt for Floating Column with certain additional provisions and Placements[9]

• Using Composite Beams under Floating Column will reduce the Vertical Displacement. [16]
• This Review shows that a horizontal displacement reduces by 182.26% (max) and a vertical displacement reduces by 140.03% (max) after infill walls provisions. [18]
• Provision of Triangular Plate under floating Column makes the Building more Stiffer. [20]

CONCLUSIONS:

From the Study of all Literature Review it was observed that Normal Columns Buildings are better as compared to Floating Columns in terms of Safety of Structure. [26] More Research has to be done on Floating Columns So as to Achieve Better Strength and Safety as per Earthquake point of view.

Following Conclusions can also be made by analyzing these Literatures:

1) Introduce Shear wall at proper positions in the soft storey can impart strength to Floating Column structure[23]
2) Using Composite Beams under Floating Columns will reduce the amount of deflection obtained as compared to RC Beams[16]
3) Storey Stiffness in floating column building can be increased by increasing ground floor column sizes. [17]
4) Torsional Irregularity occurs due to improper or unsymmetrical placement of Floating Columns. Hence They should be placed in symmetrical Positions. [17]
5) Floating Columns should be placed at center of stiffness of floors to achieve lesser Vertical Displacement[18]
6) Wall Infill used in between Floating Columns imparts Structural Strengthening to them. It also improves there response to Seismic Forces. [18]
7) Probability of Failure of Floating Column is less if it placed at outer periphery (2 shorter sides).Hence Shear Force value also depends upon Placement and Orientation of Floating Column. [19]
8) Provision of Triangular Plates under floating Columns strengthens it.It will increase Base Shear.It will also reduce value of storey drift and Displacements. [20]

In this Review, Various Studies were also carried out to overcome the drawbacks of Floating Columns. This Shows a Positive Point of view towards Research Area in the strengthening of Floating Column Buildings in Earthquake Zones.

 ISBN: 978-93-90214-19-8

Suitability of Full Replacement of Natural Sand by Manufactured Sand as Fine Aggregate in Cement Mortar

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Abstract- In present construction industry, the availability of natural sand gets exhausted due to rapid increase in construction activities. Also, good quality sand may have to be transported from long distance adds the cost of construction. Hence it becomes inevitable to use alternative materials for fine aggregates which include recycled aggregates, manufactured sand and crushed rock powder. This paper reports the experimental study of effect of full replacement of natural sand by manufactured sand on properties of cement mortar with mix of 1:3, 1:4 and 1:6. Cement mortar was prepared by using manufactured sand from different locations of Sangli district of Southern Maharashtra. Mortar cubes of size 70.6 X 70.6 X 70.6 mm were casted, cured and tested for compressive strength after 7 days, 14 days, and 28 days. Strength characteristics of cement mortar using manufactured sand as fine aggregate at various proportions was evaluated and compared with natural sand cement mortar. Results indicated that river sand can be entirely replaced by manufactured sand. Further, the compressive strength of the mortar with manufactured sand was exceeded that of the natural sand at the same water cement ratio. In contrast, slump values gradually decrease with the increasing of manufactured sand in mortar due to the higher angularity of the manufactured sand particles. Water absorption value was found increased with increase in percentage replacement of manufactured sand.

Index Terms— ***Manufactured Sand, Compressive Strength, Brick Prim, Water Absorption*.**

I. INTRODUCTION

Construction cost in India is increasing approximately by 15% every year, primarily due to increased cost of basic building materials such as bricks, steel, cement, timber etc. & of-course labour too. This has led to cost of construction to such level that it has become difficult for persons of low & middle class income group to afford a decent house. Therefore there is a need of the hour to make materials more cost effective using local & economic materials which are found in abundance nearby.

The most commonly used fine aggregate is natural river sand. The global consumption of natural sand is very high, due to the extensive use of it in concrete or mortar. In general, the demand of natural sand is high in developing countries to satisfy the rapid infrastructure growth. In this situation developing country like India is facing shortage in good quality natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. Increasing extraction of natural sand from river beds causing many problems like loosing water retaining sand strata, deepening of the river beds and causing bank slides, loss of vegetation on the bank of rivers, exposing the foundation of intake wells of water supply schemes and disturbs the ecosystems of aquatic life as well as affecting agriculture. Stone crushers are the small scale and urban/rural based industry in majority in Sangli district. One has to concentrate on the locally available materials (without requiring additional energy to treat it further) which can have a ready to use application potential. The use of manufactured sand can be one such potential material available from the towns and cities in the vicinities, but which needs laboratory and field exploration. The studies show good trends of utilizing manufactured sand in combination of cement and other admixtures as a replacement to natural sand in construction industry. However the onsite proportions of cement mortar are largely based upon the vernacular methods. Also not much seems to have been done in assessment of the quality of manufactured sand in masonry engineering properties viz. Compressive, flexural, tensile, unsupported height of wall, elastic modulus, prism test, brick mortar inter-surface bond strength which reflect the compatibility with mortar and thus a better performance as a cement mortar. This research will attempt to explore the above gaps which could lead to a better quality building product thereby enhancing the performance of buildings in India.

A. Research significance

The significance of research work is to assess the performance of manufactured sand in cement mortar for strength and to improve the overall mortar quality. The study is carried out on mortar with proportions 1:3, 1:4 and 1:6 which are generally used on site for the purpose of construction of masonry and plastering.

This work focuses on the experimental analysis that has the potential of manufactured sand to replace natural river sand in mortar. Mortars prepared should satisfy the minimum strength requirement as per IS 2116-1980 code. Thus the use of such alternatives to natural sand for mortars in masonry construction would deliver an efficient, economical and sustainable alternative to natural fine aggregates.

B. Objectives of the research

a. To assess the quality of manufactured sand from three different locations within Sangli district of Maharashtra.
b. To evaluate the performance of manufactured sand cement mortar at the proportion formulated as 1:3, 1:4 and 1:6.

II. Literature review

Ambarish Kamble (2011)[1] attempts to find strength of the hollow block masonry using granite fines. Large quantities of granite fines are generated results in solid waste management including the major environmental concerns. With the increasing awareness about the environment, scarcity of land-fill space and due to its ever increasing cost, waste materials and by product utilization like granite fines has become an alternative to disposal and fine aggregates. He states that the use of granite fines results in a good degree of surface finish and edges. The optimum replacement of granite fines to fine aggregates is 25 % results in compressive strength of 9.79 N/Sqmm and the performance of the concrete blocks increases with mechanical compaction techniques and the strength characteristics of any masonry depend on the strength and elasticity parameters of masonry units, mortar and their interactive behavior.

Appukutty P. (2013)[2] evaluates the strength performance of the fines removed from crusher dust in cement mortar for brickwork is better than natural sand. There is cost reduction of about 12.50% in brick work and 20.80% in stone masonry by replacing the natural sand. The utilization of crusher dust leads to eco-friendly construction and economic construction.

P. Chindaprasirt (2005) [3] suggest that for fairly coarse grade class-F fly ash the results obtained can be incorporated into mortars as replacement of the mixed cement for joint and plastering. The tests carried are the determination of water demand, relations between water-to-binder ratio and flow, setting time, air content, water retention, compressive strength and flexural strength shows good results. The main concern is the low water retention which would be minimized by using a better grade/finer fly ash or by incorporation of plasticizer

H. M. A. Mahzuz (2011)[05] conducts the study on performance of concrete by replacing normal sand and crushed stone aggregates by stone powder and stone chips. He states that stone powder is well appropriate for medium graded concrete for better performance in terms of strength and economy over normal sand. For mortar, stone powder is well appropriate to choose it as an alternative of sand. The availability of the stone powder is limited and its price is not defined. If the stone powder can have a price value, it is not difficult to market it and use it as an alternative of sand.

K. S. Gumaste (2004) [07] revels the problem of low quality masonry blocks used in building projects were due to several factors like "time lag" between mixing and placing of mix into mould, improper compaction, type of cement and in appropriate cement-water mix ratio. These things were found to have great and decisive effects on the strength and quality of the building blocks. The poor mixing of cement, sand and water, lack of quality control measures and low quality sand were responsible for low quality masonry.

Mayank Varshney (2014)[08] finds the construction cost in India is increasing primarily due to increased cost of building materials such as bricks, steel, cement, timber. Therefore there is a need of the hour to make materials more cost effective using local & economic materials which are found in abundance nearby. He suggests that stone dust fly ash brick manufacturing is a potential field of application wherein large-scale utilization of stone dust & fly ash is possible. The stone dust fly ash cement bricks are better alternative to conventional burnt clay bricks in structural, functional and economic aspects and can fulfill the objectives of affordable housing .This industry has the potential to consume at least 50% of the ash production in India & all the stone dust waste material.

M. Chitlange (2008)[09] conducted the tests on cubes and beams to study the strength of concrete made of quarry rock dust and compares the results with the natural sand concrete. He suggests that there is a large variation in the strength enhancement of the concrete made from artificial sand. This variation may be due to the type and strength of the parent rock, the size and shape of the particle and the dust content. He states that mixes with artificial sand as fine aggregate gives consistently higher strength than the mixes with natural sand. The sharp edges of the particles in artificial sand provides better bond with cement than the rounded particles of natural sand resulting in higher strength.

Nimitha Vijayaraghvan (2013)[11] investigates that the increasing extraction of natural sand from river beds causing many problems like losing water retaining sand strata, deepening of the river courses and causing bank slides,

ISBN: 978-93-90214-19-8

loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes and disturbs the aquatic life. She conducts experimental studies and shows that the resistance to penetration of water as proved by rapid chloride penetration test and water permeability test, is increased with increasing proportion of manufactured sand in concrete. She states that river sand can be fully replaced by manufactured sand. The use of manufactured sand in the construction industry helps to prevent unnecessary damages to the environment and provide optimum exploitation of the resources

Peter Walker (1996)[12] cazrries out experimental work on soil cement mortars and states that the effect of Slump testing proved the most reliable means of assessing soil cement mortar consistency and both the flow table and cone penetrometer tests were found to be unsuitable. He found that the water retention properties of soil cement mortars appear well suited to typical unit water absorption characteristics. Mortar strengths were closely related to cement and clay contents, but as expected were less than the average unit strengths.

Priyanka A. Jadhav (2013)[13] carried out work on strength properties of cement mortar with partial replacement of natural sand by manufactures sand. Manufactured sand has a potential to provide alternative to natural sand and helps in maintaining the environment as well as economical balance. Manufactured sand qualifies itself as suitable substitute for river sand at reasonable cost. The manufactured sand found to have good gradation and nice finish which is lacking in natural sand and this has been resulted in good cohesive cement mortar.

P. Tamililselvi (2000)[14] suggests in his work of manufactured sands are made by crushing aggregate to sizes appropriate for use as a fine aggregate. During the crushing case the manufactured sand have irregular shapes and more fine particles contributing to improved compressive strength as compared to natural sand. Due to the irregular particle shape of the manufactured sand, in addition to the reduced amount of water cement ratio, manufactured sand is more important for high strength concrete mixes. Analysis made on the influence of manufactured sand in the cost of the concrete revealed that no significant cost variation is observed for mixes with fully replacement of the manufactured sand with natural one. Manufactured sand offers important economic advantages in regions where the availability of natural sand is scarce or in cities where transportation cost is high. The use of manufactured sand in the construction industry helps to prevent unnecessary damages to the environment and provide optimum exploitation of the resources.

Shakir A. A (2013)[15] investigates that the density was strongly influenced by the increase of the quarry dust. The compressive strength ranges from 7.7 to 26.30 N/Sqmm while water absorption decreased with the increase of quarry dust. The optimum ratio of fly ash to quarry dust is found to be 1:1 since it showed the best performance with regard to mechanical properties. Manufacture of bricks using a combination of quarry dust and fly ash is feasible. The method of manufacturing suggested will contribute to sustainability and waste management. Therefore, they can be used as an alternative to conventional bricks in the building sector.

After study of above literatures the proposed study therefore recommends that quality control concepts should be applied in the production of manufactured sand. The use of acceptance sampling tests, pre-process, in-process, and post-process inspections and testing’s for all the raw materials used in mortar and application of quality control-chart for working-process should be adopted. Therefore, this study intended to identify the potential of using manufactured sand as fine aggregates in cement mortars.

III. MATERIALS

A. Cement

Ordinary Portland cement is composed of calcium silicates, aluminates and alumino ferrite. It is obtained by blending predetermined proportions of limestone, clay and other materials in small quantities which are heated and pulverized at high temperature around $1500^{o}C$ to produce ‘clinker’. The clinker is then ground with small quantities of gypsum to produce a fine powder called Ordinary Portland Cement. During this present work 53 grade OPC conforming to IS 12269-1987 was used. Some of the obtained physical properties of cement are listed in Table 1.

Table No 1 Properties of Cement

Particulars	Test Value
Fineness	4.52
Specific Gravity	3.13
Consistency	33%
Initial setting time	55 min
Final setting time	425 min

B. Manufactured sand

Manufactured sand is a substitute to river sand for construction purposes. It is produced in Sangli district of Maharashtra from hard basalt stone by crushing. The crushed sand is of cubical shape with edges and graded as a construction material. Locally available river sand as fine aggregate is replaced by manufactured sand (4.75mm to 75 micron). The test results are shown in table 2.

Table 2: Physical properties of manufactured sand

Particulars	Locations		
	Jaysingpur (J)	**Bhose (B)**	**Siddhewadi (S)**
Specific gravity	2.56	2.82	2.61
Fineness modulus	2.98	2.95	2.93
Bulk Density (Kg/Cum)	1685	1906	1744
Bulking %	17.22	18.88	20.00

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Manufactured sand from three different locations viz. J, B and S stone crusher industries was collected and sieve analysis of these samples is carried out and confirms to zone II (IS 383-1970).

C. Water

The water used for making cement mortar should be clean and free from harmful impurities like oil, alkalis, acids etc. Ordinary potable water available in the laboratory was used for making and curing the blocks. The quality of water was found to satisfy the requirements of IS 456–2000.

IV. EXPERIMENTAL INVESTIGATIONS

Experimental studies on cement mortars was carried out and reported that manufactured sand cement mortar is less workable due to angular shaped particles and rough surface texture as compared to natural river sand. Generally manufactured sand contains high fines, whereas lesser amount of clay, silt. The stone dust is the major component of these fines. The effects of particle texture and shape of fine aggregates are more predominant in cement mortar. Better interlocking of particles can be achieved by using angular shape of fine aggregates, which lead to improvement in strength.

The tests on mortar using manufactured sand at proportions 1:3, 1:4 and 1:6 were conducted as these proportions are maximally used on site for masonry construction and plastering work. Mix the cement and sand properly in dry condition with a trowel and then add water. The quantity of water shall be (p/4 +3) % of combined weight of cement and sand where, p is the % of water required to produce a paste of standard consistency determined earlier. Add water and mix it until the mixture is of uniform colour. The time of mixing shall not be less than 3 minutes & not more than 4 minutes. Immediately after mixing the mortar, place the mortar in the cube mould and prod with the help of the rod. The mortar shall be prodded 20 times in about 8 sec to ensure elimination of entrained air. Then place the cube moulds in temperature of 27 ± 2^{o} C for 24 hours.

After 24 hours remove the cubes from the mould and immediately submerge in clean water till testing. Take out the cubes from water just before testing. Testing should be done on their sides without any packing. Tests were conducted on 5 cubes of each proportion and report the average value as the test result.

The flow test is carried out for different water cement ratios from 0.6 to 1.10. The compressive strength tests are carried out on the mortar cube in the laboratory of the college. The mortar cubes of size 70.60X70.60X70.60 mm were casted for the study. The cubes were cured at room temperature and tested for compressive strength after 7 days, 14 days and 28 days of curing. To determine water absorption, the 70.6 mm x 70.6 mm x 70.6 mm size mortar cubes were prepared and immersed in water for 28 days curing. Then these specimens were oven dried for 24 hours at the temperature 85°C and again weighed. This weight was noted as the dry weight (W1. After that the specimen was kept in water for 24 hours and again these are weighted and noted as the wet weight (W2).

V. Result and discussion

A. Specific Gravity

This is a very important property of mix design. Specific gravity of fine aggregate (sand) is the ratio of the weight of given volume of aggregates to the weight of equal volume of water. Oven dried aggregate passing through 4.75mm sieve is taken. Experiment is conducted according to IS 2386 (PART III): 1963. The test results are given in table 3.

Table 3: Specific gravity of manufactured sand

Sr. No.	Specification	Locations		
		Jaysingpur (J)	Bhose (B)	Siddhewadi (S)
1	Specific Gravity	2.56	2.82	2.61

From all given samples J, B and S, sample no 2 has maximum specific gravity i.e. 2.82. Specific gravity of the sand is generally indication of its quality. A low specific gravity may indicate high porosity and therefore poor durability and low strength. The average value of the test samples should not less tahn2 and not more than 3. The obtained values of all the three samples are good indicative of specific gravity.

B. Water absorption test

The 70.60 mm x 70.60 mm x 70.60 mm size mortar cube were prepared and immersed in water for 28 days curing. Then these specimens were dried in ventilated oven for 24 hours at the temperature 85°C and weighed. This weight was noted as the dry weight (W1). After that the specimen was kept in water for 24 hours. Then this weight was noted as the wet weight (W2).

Percentage of water absorption = [(W2– W1) / W1] x 100. The test results are shown in table 4.1, 4.2 and 4.3

Table 4.1: Water absorption for manufactured sand cement mortar block at 1:3

Sample	1:3		
	Jaysingpur	Bhose	Siddhewadi
Dry weight (gm) W1	0.849	0.86	0.863
Wet weight (gm) W2	0.881	0.889	0.895
Difference	0.032	0.029	0.032
Moisture content	3.8	3.4	3.71

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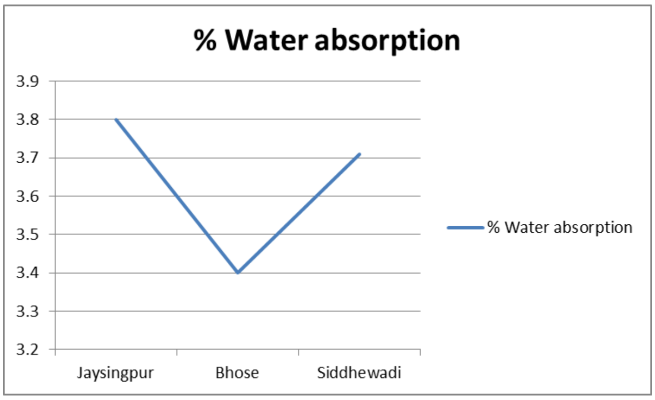
Table 4.2: Water absorption for manufactured sand cement mortar block at 1:4

Sample	1:4		
	Jaysingpur	Bhose	Siddhewadi
Dry weight (gm) W1	0.851	0.854	0.863
Wet weight (gm) W2	0.883	0.885	0.896
Difference	0.032	0.031	0.033
Moisture content	3.76	3.63	3.82

Table 4.3: Water absorption for manufactured sand cement mortar block at 1:6

Sample	1:6		
	Jaysingpur	Bhose	Siddhewadi
Dry weight (gm) W1	0.856	0.866	0.851
Wet weight (gm) W2	0.891	0.902	0.896
Difference	0.035	0.036	0.045
Moisture content	4.1	4.1	4.31



Graph 1: Water absorption for manufactured sand cement mortar blocks

Water absorption of cement mortar is an important factor is classifying its durability. Generally, mortar of low water absorption will afford better protection to reinforcement within it, than mortar of high water absorption. The average absorption of the test samples shall not be greater than 5% with no individual unit greater than 7%. It can be observed from graph 1 that, all sample have water absorption less than standard maximum allowed. Water absorption value increases with increase in percentage replacement of manufactured sand. While increasing the cement-sand ratio the water absorption value also increases

C. Fineness modulus

Fineness modulus of sand is an index number which represents the mean size of the particles in sand. It is calculated by performing sieve analysis with standard sieves. Weight of sample taken for sieve analysis is 2000 gm. The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fineness modulus.

The natural sand having fineness modulus of 2.78 and conforming to zone II as per IS: 383-1970 was used for the experimentation after washing it with clean water. The results of aggregate sieve analysis are expressed by a number called Fineness Modulus obtained by adding the sum of the cumulative percentages by mass of a sample aggregate retained on each of a specified series of sieves and dividing the sum by 100. The test results are shown in table 5.

Table 5: Sieve analysis manufactured sand

I.S. Sieve No.	% Weight Passing	% Weight Passing	% Weight Passing
	Jaysingpur	Bhose	Siddhewadi
4.75 mm	96.60	93.80	94.80
2.36mm	91.20	88.40	90.20
1.18mm	77.40	77.60	82.80
600 micron	41.20	55.40	51.30
300 micron	25.20	24	22
150 micron	9.80	8.20	9.60
Fineness modulus	3.414	3.474	3.507

The Fineness Modulus of Manufactured sand from locations as J, B and S is found to be 3.414, 3.474 & 3.507 are just above to limit of 3.10 as per IS 2386 Part III-1963. From above table we can see that the result of all the samples are falling in Grading limits for zone II as compare to grading limits of Zone II sand as per IS 383-1970, hence suitable for masonry application.

D. Bulking of Fine Aggregate

The test was conducted according to the procedure laid down in IS 2386 (PART III): 1963.

The volume increase of fine Aggregate due to the presence of moisture content is known as bulking. This is due to the fact that moisture causes a film of water around sand particles which results in the increase of volume of sand, for moisture content of about 5 to 8%, this increase of volume may be a much as 20 to 40%, depending upon the grading of sand. The finer the material, the more will be the increase in volume for given moisture content. This phenomenon is known as the bulking of sand. Bulking is an intrinsic property of natural sand. This is very important property in volume batching of aggregate. The test results are given in table 6.1, 6.2 and 6.3.

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Table 6.1: Bulking of manufactured sand from Jaysingpur

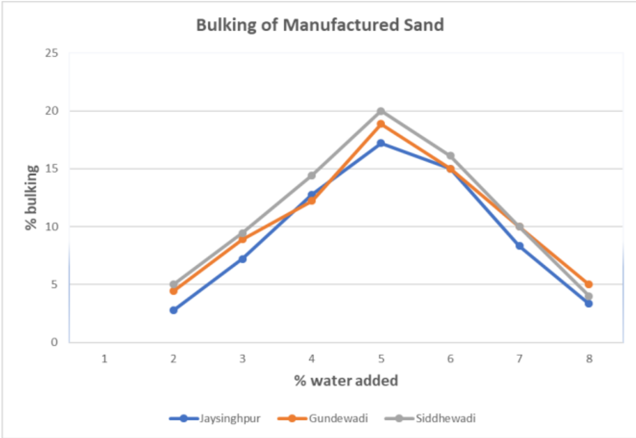
% of water added	Initial height	Final height	% Bulking
Jaysingpur			
2	180	185	2.78
4	180	193	7.22
6	180	203	12.78
8	180	211	17.22
10	180	207	15.00
12	180	195	8.33
14	180	186	3.33

Table 6.2: Bulking of manufactured sand from Bhose

% of water added	Initial height	Final height	% Bulking
Bhose			
2	180	188	4.44
4	180	196	8.89
6	180	202	12.22
8	180	214	18.88
10	180	207	15.00
12	180	198	10.00
14	180	189	5.00

Table 6.3: Bulking of manufactured sand from Siddhewadi

% of water added	Initial height	Final height	% Bulking
Siddhewadi			
2	180	189	5.0
4	180	197	9.44
6	180	206	14.44
8	180	216	20.00
10	180	209	16.11
12	180	200	10.00
14	180	185	4.00



Graph 2: Bulking of manufactured sands

It can be observed from graph 2 that the bulking of fine aggregate ranges from 15-30%. As the bulking of manufactured sand is less than 20 %, it shows that the initial moisture content is less than 4%, hence the use of manufactured sand in mortar can be accepted.

E. Bulk density

Bulk density of aggregate is the mass of a unit volume of bulk aggregate material, in which the volume includes the volume of individual particles and volume of voids between the particles. It is expressed in kg/m3.

Weight of sample taken for sieve analysis =500 gm.

Bulk density of aggregate is the mass of a unit volume of bulk aggregate material, in which the volume includes the volume of individual particles and volume of voids between the particles. The test results are given in table 7.

Table 7: Bulk density of manufactured sand

Sr. No	Bulk Density	Jaysingpur	Bhose	Siddhewadi
1	Loose kg/m^3	1685	1906	1744
2	compacted kg/m^3	1826	2043	1955

Bulk density is the ratio of mass to the unit volume of aggregate. From above table we can see that the result of all the samples have slightly higher bulk density than natural sand.

F. Flow test

Flow test is performed on mortar in order to establish relationship between flow and water cement ratio. Determination of workability of a given sample of mortar is done by conducting flow table test. Mortars with Manufactured sand exhibit better flow characteristics. Flow tests were performed on the three types of mortars in order to establish relationships between flow and water-cement ratio. Mortars with The test results are given in table 8, shows the

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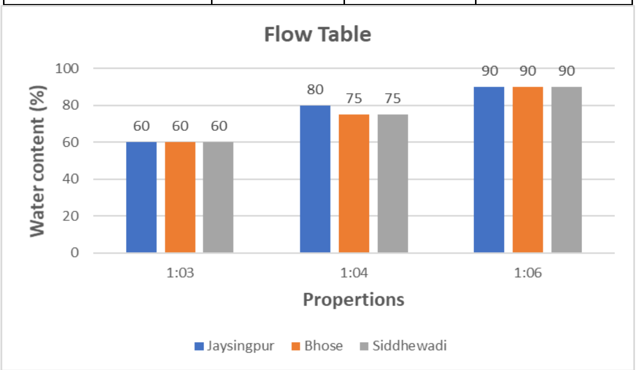
flow versus water-cement ratio relationships for the 1:3, 1:4 and 1:6 cement mortars respectively.

Table 8: Flow test of manufactured sands

Proportion	1:3	1:4	1:6
Sample	Flow Values %		
Jaysingpur	60	80	90
Bhose	60	75	90
Siddhewadi	60	75	90



Graph 3: Flow test of manufactured sands

It can be observed from graph 3 that the flow value of mortar with manufactured sand decreases with increase in percentage of manufactured sand. Manufactured sand exhibits better flow characteristics. In case of 1:6 cement mortar, to achieve 100 % flow the water required is about 90% using manufactured sand. Similarly, for 1:4 cement mortars, it is 75 % and for 1:3 cement mortars it is 60%. Flow value for manufactured sand cement mortar is about 25% less with respect to natural sand cement mortar. To achieve a given flow value, mortar with manufactured sand requires lower water-cement ratio. Lower water-cement ratio results in better characteristics for the mortars in hardened state.

G. Compressive Strength

The compressive strength of mortar were determined in accordance with IS 2250-1981, by conducting tests on 70.6 mm X 70.6 mm X 70.6 mm cube specimens at 7th, 14th & 28th days. The test was carried out in the compression testing machine of 2000 KN capacity. The cubes were placed in the compression testing machine and the load was applied at the rate of approximately 140N/Sqmm/min until the failure of the specimen. The average value of three samples was taken as strength. The test results are given in table 9.1, 9.2, and 9.3.

Table 9.1: Compressive strength at 1:3 (N/Sqmm)

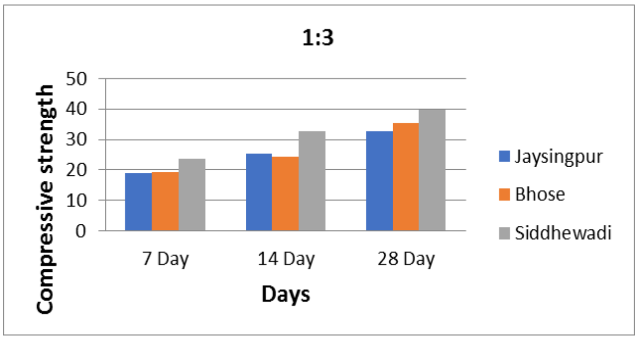
Sample	1:3		
	7 Day	14 Day	28 Day
Jaysingpur	18.94	25.31	32.65
Bhose	19.42	24.28	35.31
Siddhewadi	23.75	32.65	39.59

Table 9.2: Compressive strength at 1:4 (N/Sqmm)

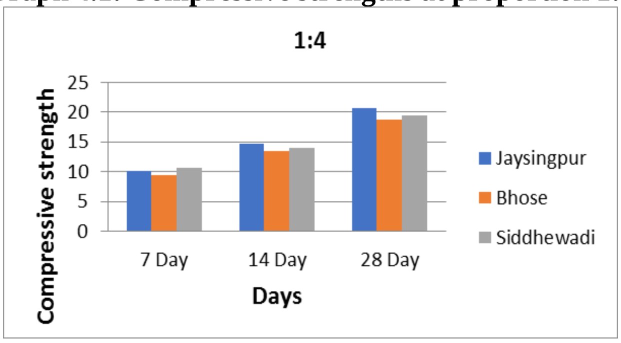
Sample	1:4		
	7 Day	14 Day	28 Day
Jaysingpur	10.1	14.69	20.61
Bhose	9.38	13.47	18.77
Siddhewadi	10.66	14.08	19.38

Table 9.3: Compressive strength at 1:6 (N/Sqmm)

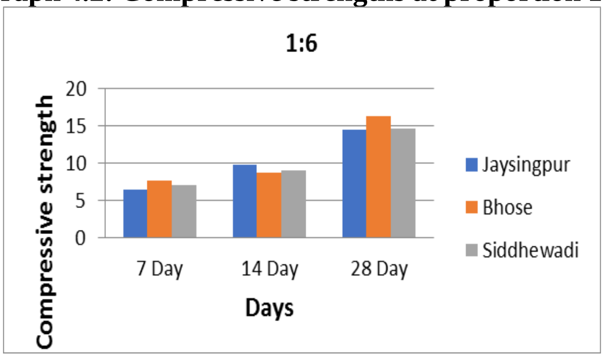
Sample	1:6		
	7 Day	14 Day	28 Day
Jaysingpur	6.52	9.79	14.49
Bhose	7.67	8.78	16.33
Siddhewadi	7.05	8.98	14.69



Graph 4.1: Compressive strengths at proportion 1:3



Graph 4.2: Compressive strengths at proportion 1:4



Graph 4.3: Compressive strengths at proportion 1:6

It can be observed from graphs 4.1, 4.2 and 4.3 that compressive strength increases with age as expected. The strength of the cement mortar increases with increase in percentage of cement. Compressive strength of cement mortar with 100 % manufactured sand is 70% more when compared to cement mortar with natural sand as fine aggregate.

 ISBN: 978-93-90214-19-8

Test results were drawn to cement mortar at proportions of 1:3, 1:4 and 1:6 having water cement ratio as 0.40 to 0.60. Mortar mixes revealed an increase in compressive strength up 39.59, 20.61 and 16.33 N/Sqmm for proportions of 1:3, 1:4 and 1:6 respectively. The value of compressive strength of manufactured sand cement mortar is satisfied the criteria of IS 2250-1981 i.e. minimum compressive strength for 1:3, 1:4 and 1:6 mortar cube at age of 28 days is 7.5 N/Sqmm, 4.5 N/Sqmm and 3 N/Sqmm respectively. This may be due to the fact that 100% replacement of natural sand by manufactured sand may show the reaction with full filler capacity. In this study we observe that the overall strength of mortar is higher are compared with natural sand cement mortar. It can be concluded that 100% replacement of natural sand by manufactured sand will yield the maximum strengths for cement mortar.

VII. Conclusion

The effect of full replacement of natural sand by manufactured sand in cement mortar from three locations is compared with natural sand cement mortar at various proportions as 1:3, 1:4 and 1:6. The compressive strength of manufactured sand revels higher strength as compare to with natural sand cement mortar. The manufactured sand from Siddhewadi stone crusher has more strength as compared with natural sand cement mortar. The values of compressive strength for other two sources as Jaysingpur and Bhose seem to be greater than natural sand cement mortar. The all samples of manufactured sand have a potential to provide alternative to natural sand and helps in maintaining the environment as well as economy too. Non availability of natural sand at reasonably cost, forces to search for alternative material. Manufactured sand qualifies itself as suitable substitute for river sand at reasonable cost. The manufactured sand found to have good gradation and nice finish which is lacking in natural sand and this has been resulted in good cohesive cement mortar.

Hence we can conclude that

1. The manufactured sand has compatible properties with natural sand
2. The properties are within the range specified by the Indian standard code of practice.
3. Manufactured sand is available for reasonable cost and availability in the market where as natural sand is costlier and scarcely available.

In this study we observe that the overall strength of mortar is higher are compared with natural sand cement mortar. It can be concluded that 100% replacement of natural sand by manufactured sand will yield the maximum strengths for cement mortar. Hence the manufactured sand has almost same properties as that of natural sand. Therefore manufactured sand has a potential to provide alternative to natural sand. The manufactured sand can be used as an alternative building material to natural sand.

VI. Acknowledgement

The authors would like to thanks to Dr. P. S. Patil, Associate Professor, Department of Civil Engineering, Rajarambapu Institute of Technology, Rajaramnagar, Islampur, Maharashtra, for giving all the encouragement needed which kept my enthusiasm alive.

VII. References

1. Ambarish Kamble, Manjunath A.S, Dr. Renukadevi M. V., Dr. K. S. Jagdish, (2011) R.V. College of Engineering, Banglore "Effect of Granite fines on strength of hollow concrete block". IJAT/Vol –II/Issue IV E-ISSN 0976-3945: PP 475-479.
2. Appukutty P and Murugesan R (2013), P.A. Polytechnic College, Pollachi, India Sri Ranganathar Engineering College, Coimbatore, India, "Substitution of quarry dust to sand for mortar in brick masonry works", International journal on design and manufacturing technologies, vol. 3, no 1, January 2013
3. P Chindaprasirt, N Buapa, and HT Cao (2005) Mixed cement containing fly ash for masonry and plastering work. Construction and Building Materials, October 2005, Construction and Building Materials 19(8):612-618, DOI: 10.1016/j.conbuildmat.01.009, 19(8):612, 618.
4. Donghui Huang, Haitao Zhao, Qi Xiao2 and Shiping Zhang3 (2014), "Influence of Pore Structure on Compressive Strength of Cement Mortar" Hindawi Publishing Corporation Scientific World Journal, Volume 2014, Article ID 247058.
5. H. M. A. Mahzuz, H. M. A. Mahzuz, A. A. M. Ahmed and M. A. Yusuf (2011), "Use of stone powder in concrete and mortar as an alternative of sand", African Journal of Environmental Science and Technology Vol. 5(5), pp. 381-388, May 2011, AJEST, ISSN 1996-0786, 2011
6. J. Karthick and V. Gopi (2014), Sree Sowdambikia college of engineering, Aruppukottal " Experimental practice on high volume fly ash and stone waste block alternative to conventional bricks/blocks", IJARET, ISSN 2394-6814, Vol 1, Issue 1.
7. K. S. Gumaste, KSN Rao, BVV Reddy, and KS Jagadish, (2004)," Properties of burnt bricks and mortars in India", Masonry International J. Vol. 17, No.2 August 2004, 45-52.
8. Mayank Varshney, Meena Varshney and Amit Sharma, (2014) Jagannath University, Jaipur "Techno- Economic feasibility study of stone dust fly ash cement bricks over ordinary clay bricks in affordable housing"., IJSET 1st Jan 2014 Vol No 3, Issue No 1, PP 63-69
9. M. R. Chitlange, Dr. P. S. Pajgade and Dr. P. B. Nagarnaik, (2008), " Experimental Study of Manufactured Sand Concrete", First International Conference on Emerging Trends in Engineering and Technology,

978-0-7695-3267-7/08, 2008 IEEE, 1109/ICETET.2008.164
10. M. Adams Joe M, A. Maria Rajesh, P. Brightson, M. Prem Anand, (2013), "Experimental Investigation on The Effect Of Manufactured sand In High Performance Concrete", American Journal of Engineering Research (AJER)e-ISSN : 2320-0847 p-ISSN : 2320-0936Volume-02, Issue-12, pp-46-51.
11. Nimitha Vijayaraghavan and Dr. A. S. Wayal (2013), "Effect of Manufactured Sand on Durability Properties of Concrete ", American Journal of Engineering Research (AJER) 2013, Page 437, e-ISSN: 2320-0847, p-ISSN: 2320-0936, Volume-02, Issue-12, pp-437-440.
12. Peter Walker and Trevor Stace (1996), "Properties of some cement stabilised compressed earth blocks and mortars", Dept. of Resource Engineering, University of New England, Armidale, NSW 2351, Australia Materials and Structures, Vol. 30, November 1997, pp. 545-551, July 17, 1996
13. Priyanka A. Jadhav and Dilip K. Kulkarni (2013), "Effect of replacement of natural sand by manufactured sand on the properties of cement mortar" international journal of civil and structural engineering, Volume 3, No 3, 2013, research article ISSN 0976 – 4399
14. P. Tamililselvi (2000), "Experimental studies on partial replacement of natural sand with manufactured sand", Journal of advance science in chemistry, ISSN 2321-807X, Volume 12.
15. Shakir A. A., S Naganathan, and KN Mustapha (2013), "Properties of bricks made using fly ash, quarry dust and billet scale". Construction and Building Materials, 41:131, 138.
16. Syed Humayun Basha and Hemant B Kaushik (2015), "Non-linear Behavior of Weak Brick-Strong Mortar Masonry in Compression", Springer 2015, Advances in Structural Engineering, 978-81-322-2187-6,185.
17. IS 383 – 1973 – Reaffirmed 2011 (Third Revision) for Course and fine aggregates from natural sources for concrete.
18. IS 2116- 1980 – Reaffirmed 1998 (First Revision) for sand for masonry mortars
19. IS 2250 -1981 - Reaffirmed 1995 (First Revision) for preparation and use of masonry mortars
20. Guide for users of coal ash. National Thermal Power Corporation, New Delhi, 1999.

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Key Publications in international journals, Dr. P. S. Patil R.D. Patil, "Studies on effect of Depth on Strength and Behaviour of RC Beam", International Journal of Engineering Sciences Research IJESR, Vol. 02, Issue 3, July 2011, ISSN 2230-8504; e-ISSN-2230-8512, pp-191-195.
Dr. P. S. Patil,S. B. Kumbhar ,Dr. M. R. Shiyekar, "Parametric Study of Dynamic Behaviour of Cable Stayed Bridges", International Journal of Engineering Sciences Research IJESR, Vol. 02, Issue 3, July 2011, ISSN 2230-8504; e-ISSN-2230-8512, pp-212-219.
S.S. Shinde,Dr. P.S. Patil, "Parametric Study on Slender column for flat Plate Structure", International Journal of Research in Engineering and Technology IJRET, Vol. 4, Issue 4ISSN 2319-1163, JUNE 2015, 452-456.
S.P. Belgundkar,Dr. P.S. Patil, "Analysis of traffic induced vibrations of bridge structure under different vehicle parameters", International Journal of Emerging Technology and Advanced Engineering, Volume 5, Issue 5, May 2015 ISSN 2250-2459.
Sujan V. Kagale,P. S. Patil, "Experimental evaluation of RCC beam under elevated temperature and its GFRP retrofitting", Journal of Structural Engineering, ISSN 0970-0137, Vol. 42, No. 4, Oct.-Nov. 2015, 336-340.

Publications / Presentation (in peer-reviewed conferences held in India)
Bapat S.D., Dr. P.S. Patil, "A comparative study of behavior of RCC and steel multistoried structures", Proceeding of the International Conference on Advances in Civil Infrastructure and Development of Smart Cities (ICACIDS-2K16) at RIT Rajaramnagar, ICACIDS-2K16 FEBRUARY 26 to 28, 2016ISBN:978-93-84659-32-5, 82-91.
Pramod B. Salgar, Dr. P. S. Patil, "Study the behavior of light weight concrete with lightweight Expanded Clay aggregate (LECA)", Proceeding of the International Conference on Advances in Civil Infrastructure and Development of Smart Cities (ICACIDS-2K16) at RIT Rajaramnagar, ICACIDS-2K16 FEBRUARY 26 to 28, 2016ISBN:978-93-84659-32-5, 129-134.
Kore. R. S. and Dr. P.S. Patil, "Study of performance of lean duplex stainless steel built-up I column section under axial load", Proceeding of the International Conference on Advances in Civil Infrastructure and Development of Smart Cities (ICACIDS-2K16) at RIT Rajaramnagar, ICACIDS-2K16, FEBRUARY 26 to 28, 2016,ISBN:978-93-84659-32-5, 291-299.

Craftsmanship and *Imah Panggung* Architectural Technology as Ideas for Flood-Friendly houses of Sundanese people in Indonesia

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Abstract*—*Craftmanship and imah panggung architectural technology in traditional Sundanese society seems to have escaped the attention of researchers because it is considered unpopular and out of date. People are more familiar with modern, luxurious, and aesthetic architecture with high technology. Modern architecture is not able to answer the problem of flooding, many houses are submerged and destroyed. Meanwhile, the traditional houses in the village can survive and are not destroyed by the disaster. This is the reason behind the research on craftsmanship and imah panggung architectural technology as ideas for flood-friendly houses for Sundanese people in Indonesia case in Cieunteung village, Bandung regency, West Java province. The research method used is descriptive-qualitative with case studies. This research resulted in two important things: (1) The concept of imah panggung can provide comfort during floods; (2) A typical roof typology, relatively easy assembly process, and light impressions make housing costs affordable for all levels of society; (3) The craftsmanship and technology to build the imah panggung priesthood are all done manually based on the sharp instincts and experiences of the tukang wangunan or dulah (builders).

Index Terms— ***Craftmanship, technology, imah, flood-friendly.***

I. INTRODUCTION

West Java or what is often called Tatar Sunda is one of the many areas in Indonesia that are often hit by floods. Nurulliah [1] in the general daily Pikiran Rakyat newspaper (10/02/2020) noted that in early 2020 the province with the second largest population after Jakarta was ranked the second most disasters in Indonesia. Kurniawan, et al. [2] in the BNPB states that all regions in West Java are in the high-risk category with a score of 102 to 250, and Cianjur is in the first place nationally (score 250). Besides, during 2020 West Java the dominance of hydrometeorological disasters, such as floods, flash floods, and strong winds that occurred in several areas such as Bandung, Sukabumi, Bogor, and Cianjur. The geographical conditions of West Java, which are often crossed by large rivers, such as Citarum, Cisangkuy, Cisanggarung, and Cisadane, have the potential to cause flooding due to excessive water volume or due to bad behavior by the people who throw garbage into the river. The rainy season around September to the end of February resulted in the river's water level rising, uncontrolled, and entering human settlements around the river due to clogged drains or poor drainage systems, eventually major flooding. Abundant rainwater should be a blessing for human life for the necessities of life and life. This is not the case, for some areas in West Java that are regularly flooded, abundant rainwater is a problem, because rivers, which are ideally able to accommodate the volume of water and flow it downstream, turn out to be tides [3]. Human behavior that does not pay attention to the environment, littering, and constructing buildings on the riverbank without paying attention to the river boundary line (*garis sempadan sungai*/GSS) or the right of way (ROW) is a big problem for flooding [4].

Cieunteung village in Baleendah district, Bandung regency, West Java province was chosen as the locus and focus of the research with the consideration that this area is the affected by the flood, such as Jambatan, Uwak, Muara, Cigosol, and Ciputat villages in Andir sub-district, Baleendah district. The water level between 20-250 cm with a puddle of 1-3 days soaked 5,242 houses, 8 schools, 35 places of worship, and 9 families had to evacuate. The provincial, district, and part of the community have considered the loss due to the impact of the floods since the construction of the retention pond (2017-2018) and the implementation of the *Citarum Harum* program, although it is not yet a complete solution to overcoming floods. Communities around the Citarum tributary must remain vigilant because floods can come suddenly.

Imah panggung architectural of Sundanese traditional community has become flood-friendly house ideas whose shape can be adapted to the needs of the affected communities in Cieunteung village. The house can be proposed to the government of West Java province and Bandung regency as a model for a flood-friendly house. For the long-term program, the *panggung* system can be developed into a flood-friendly house model throughout Indonesia by the local wisdom of their respective traditional architecture. This program is very promising because it is not only a disaster-adaptive building but also has the potential for disaster mitigation tourism so that tourists who visit can see and learn first-hand about its construction, structure, and architecture. This is by the government's strategic plan from President Susilo Yudhoyono to President Joko Widodo through the Ministry of Tourism and Creative Economy, which has been aggressively implementing village tourism programs throughout Indonesia. Among the many types of tourism offered, researchers offer different ideas in the form of disaster mitigation tours that are not yet fully known and popular among the community. This is the background for researching *imah panggung* as home tourism ideas for disaster mitigation, especially floods. This study aims to make flood-friendly houses as tourism-based flood disaster mitigation in Cieunteung village. This disaster mitigation tour can be a learning medium for tourists to see and study the architecture, structure, and construction of their houses directly.

II. LITERATURE REVIEW

A. Definition of Flood

The term and definition of flood according to Suripin (2004) is a condition in which water cannot be stored in the drainage channel (river) or water flow is blocked in the drain. According to Schwab, Frevert, Edminster, and Barnes (1981) floods are an overflow or inundation of rivers or other bodies of water caused by high (excessive) rainfall, melting snow, or the presence of tidal waves that flood most of the plains. Meanwhile, Hewlett (1982) states that flooding is a flow in the form of a puddle of water that can have an impact on economic losses and even loss of life. In this case, the flow of river water that flows exceeds the normal limit (river capacity), so that the water flows through the river cliffs and inundates the area around it. Based on the three definitions above, the terminology of flooding is defined as a natural phenomenon due to high rain intensity which causes mass water reservoirs such as rivers to be unable to receive and accommodate large (excessive) volumes of water due to disruption of waterways so that they rise to land surface and settlements. According to Kodoatie and Sugiyanto (2001), flooding can be caused by various factors. In general, these factors are grouped into two causes, namely: (1) Due to natural conditions or due to natural causes; (2) As a result of human behavior or because of actions that damage the environment.

B. Sundanese Traditional of Architecture

The form of Sundanese houses is an *imah panggung*, which is a classed house using an *umpak* or *tatapakan* (stone foundation). According to Adimihardja and Salura [5], the form of the *imah panggung* that dominates the building system in Tatar Sunda has both technical and symbolic functions. Technically, the house on stilts has three functions, namely (1) *Panggung* (stage) not disturbing the water infiltration area; (2) *Kolong* (space underfloor) as conditioning medium with cross flowing air for warmth and coolness; (3) *Kolong* also used to store firewood supplies and so on. The symbolic function is based on the belief of the Sundanese that the world is divided into three namely *Buana Larang* or *Ambu Handap* (underworld/profane), *Buana Panca Tengah* or *Ambu Tengah* (middle world/neutral), and *Buana Nyungcung* or *Ambu Luhur* (upper world/sacred) [3]. In mythology related to agriculture, the Sundanese people respect *Nyi Pohaci Sanghyang Sri* who is considered the incarnation of rice [6]. Therefore, paddy or rice is always stored properly in a special place called *goah* for rice and *padaringan* for cooking and agricultural equipment. If there is a lot of rice, then to store it, a *leuit* or rice barn is provided [7].

C. Philosophy and Basic Principles of Flood-Friendly

The philosophy of flood-friendly houses can be derived from the meaning of the term "*friendly*". Poerwadarminta [8] states that the term "*friendly*" (adjective) means kind-hearted, attractive to the language, sweet in speech and nature, sociable, friendly, and warm. From this understanding, the most appropriate explanation for the definition of "*friendly*" in the context of the flood is friendly. In English, friendly is called friendly; "*able to understand and follow and not damage*", which means being able to understand and follow and not destroy [9]. The philosophy of "*friendly*" is a house that is specially designed, able to be friends, able to understand the needs of residents, and not to damage the environment. Flood-friendly houses have a dual function, during the rainy season residents work on the upper floors, while during the dry season residents can carry out activities on the upper and lower floors [3].

The basic principle of flood-friendly houses has yet to be standardized. As a basis for understanding, we can use the terminology of ecological buildings which means very close to "*flood friendly*". According to Frick and Suskiyatno [10],

ISBN: 978-93-90214-19-8

there are six basic principles of ecological building, namely being able to: (1) Adjust to local environmental conditions; (2) Adjusting and saving non-renewable natural energy sources and energy use; (3) Caring for the potential of surrounding natural resources, such as air, land, and water; (4) Reducing dependence on central energy systems (electricity, water) and waste (wastewater, garbage); (5) To independently produce daily necessities for its residents; (6) Properly manage the natural resources around the planning area for the building system, both related to building materials and utilities (energy sources, water supply). Based on Frick's opinion above, the core of a flood-friendly house is "*ecological*", meaning that it is very close to the surrounding environment.

D. Craftsmanship and Technology

Ibn Khaldun, a great scholar from the Middle East, explains the terminology of craftsmanship as "*malakah*" which means expertise in practical work related to reason. Because of its practicality, it is connected with the body and feeling. So skills related to body and feeling can be obtained more perfectly and more easily through direct contact in bodily and sensory problems, which is the most perfect acquisition [11]. Poerwadarminta [8] explains craftsmanship (noun) means expertise or skills, while people who are skilled or skilled in certain fields are called craftsmen. In the English dictionary, craftmanship has the following meanings: (1) Skills in an occupation or trade, which means skills or expertise in a particular job or trade; and (2) The work of a craftsman, meaning a work produced by an expert [9]. Based on some of these opinions, it can be concluded that the notion of perceptions is the expertise or skill of a job that is done by involving the body, mind, and feelings. There are two aspects to understanding perceptions in this study, namely: (1) Implicit knowledge or tacit knowledge; and (2) Appropriate technology.

The word "*technology*" comes from Greek, namely "*techne*" means expertise and "*logos*" means science. Technology refers to objects that are used to facilitate human work so that it feels lighter by using tools, such as machines, tools, digitalization, electrical, hardware, and others [12]. Havery [13] states that technique comes from the root word "*technique*", which means a rational procedure so that interrelated components can become one unit. Poerwadarminta [8] emphasizes technology more to methods or systems of doing something. Based on these opinions, the keyword for technology is rational or logical (makes sense). Technology helps human activities in various ways by using the ease of tools and the ability of logic (reason). The ability to think logically is the main provision of life for humans to be able to empower all abilities and solve the problems at hand [Putra in 14]. About logic, technology is one of the thinking concepts that prioritizes reason, ratio, objectivity, an empirical, factual, laboratory, and replicable [15].

III. OBJECTIVES OF THE STUDY

Research on craftsmanship and architectural technology of the Sundanese community *imah panggung* is still very small, even hard to find. The purpose of this research is to reveal the craftsmanship and *imah panggung* technology that can be a solution to various disasters, especially floods.

IV. RESEARCH METHODOLOGY

This study uses a descriptive-qualitative method with a case study approach. This method is carried out through 3-M procedures, namely: *Mendeskripsikan* (describing), *Menggambarkan* (describing), and *Menceritakan* (telling in writing) based on the results of surveys or field observations regarding situations in areas that have the potential for flood disasters. To observe the house understudy is done by observing physical traces, in three ways: product use, adaptation for use, and display self and public messages [16]. The process of collecting data or information is carried out in two ways namely literature study and field studies. Data analysis was carried out in three stages: (1) Preparation, meaning that the initial activity stage was to examine each data or information by selecting and sorting; (2) Processing, meaning the stages of activities to process and display data or information to make it more structured, measurable, and communicative; (3) Analysis, meaning that the final activity stage of separation and systematic checking of information [17].

V. RESULT AND DISCUSSION

A. Cieunteung as a “Subscribe to Flood” village

Figure 1. Research location in Cieunteung village

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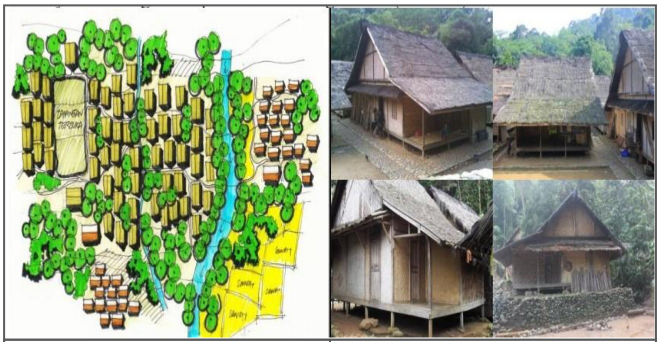
Cieunteung village is one of the most densely populated settlements in Baleendah District (fig. 1). The masses of the buildings in the village were lined up very closely, almost not far apart. The houses are connected through small roads, even in the form of aisles or alleyways that are 1-1.2 meters apart. This condition affects comfort and safety, especially evacuation when there is a flood. Based on interviews with the heads of RT 01 and RW 28, there was a big flood in Baleendah district occurs from 1986 to 2019 with an average water level intensity of 2 meters with a puddle length of ± 2 weeks. The total population in the sub-district is 1,908 people / km2 with a total population of 3,142,198 people and an area of 580.2 hectares. In 2018-2020, floods still occur with varying altitude intensity and inundation length. Although retention ponds have been built, the overflow of water from the Citarum tributary continues to enter residential areas (fig. 1).

B. Comparative Study of Sundanese community Craftmanship and Imah Panggung Technology in Baduy village and Naga village

Baduy is a popular term for the Kanekes community in Banten. Kanekes or Baduy is located in Leuwidamar district, Lebak regency, southern Banten province, Indonesia. The houses of the Baduy community are in the form of *panggung* (stilt house), which have a height of ± 40-70 cm from the ground [18]. *Panggung* (fig. 2) has a cosmological meaning related to the Baduy people's belief system about the world. They know three worlds: *Buana Nyungcung*, *Buana Panca Tengah*, and *Buana Larang*. These three worlds are arranged vertically with *Buana Nyungcung* at the top, followed by *Buana Panca Tengah* (sky) and *Buana Larang* (earth). Between *Buana Nyungcung* and *Buana Panca Tengah* there is *Bumi Suci Alam Padang*, where *Nyai Pohaci Sanghyang Sri* or *Dewi Padi* (Rice Goddes) resides [19]. The location of the house is between heaven and earth, therefore the *tihang* (pillar) is placed under which there is a *umpak* (foundation) as a link between the earth and the sky. The *panggung* form is believed to be the middle world (neutral) between *Buana Panca Tengah* and *Buana Larang*. They believe that the house on stilts is the center that has neutral power between the two worlds [20]. The *imah panggung* in Baduy village (fig. 2) is arranged based on three main structures, namely: (1) The lower part shows the basic components as the first layer for the strength of the house which consists of land (*lelemahan* or *taneuh*) and foundation (*umpak* or *tatapakan*); (2) The middle part is a component of the building body as the second layer consisting of a floor (*amben*) and a wall (*pinding*); (3) The top shows the third layer of strength components consisting of roof (*suhunan*).

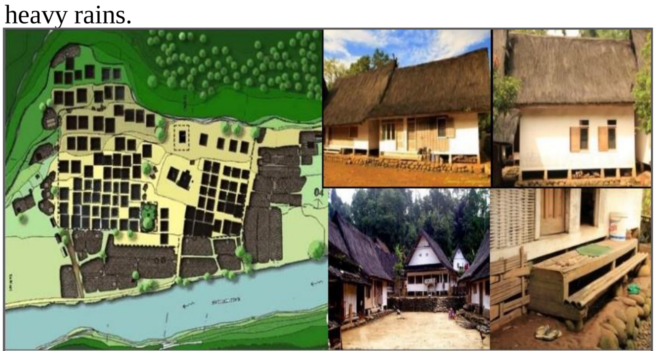


Site plan of Baduy village	*Imah panggung* in Baduy village

Figure 2. Site plan and *imah panggung* in Baduy village

Naga village is located in Neglasari village, Salawu district, Tasikmalaya regency, West Java province, Indonesia. Hermawan [21] explained that the name "*naga*" in the village comes from the word "*nagawir*" or "*NAGAwir*" (in Sundanese), which means on the edge of a cliff (*na* = in; *gawir* = the edge of a cliff). This is based on the position or location of Naga village which is on the edge of a cliff (*gawir-gawir nu lungkawing*), which means between the edges of steep ravines. The house is required to be in the form of *panggung* (fig. 3), that is, a classed house with a height of ± 35-50 cm from the ground. The people of Naga village view that the *panggung* is closely related to the cosmology of the universe; (1) *Ambu Handap* (underworld/profane) is manifested in the form of *umpak* as a foundation; (2) *Ambu Tengah* (middle world/neutral) is manifested in the form of walls and floors; (3) *Ambu Luhur* (upper world/sacred or holy) is applied to the roof. *Imah panggung* position between the upper and underworld or neutral [21]. They believe that the *imah panggung* is the core of the balance of the power of the three worlds.

Structurally, the *imah panggung* (fig. 3) has three components, namely: (1) The lower structure as the basis for strength in the form of *lelemahan* or *lemah* (land) and *umpak* or *tatapakan* (stone foundation); (2) The central structure as a content component consists of *talupuh* (floor) and *pangadeg* (wall); (3) The upper structure shows the protective component in the form of a *suhunan* (roof). In Naga village, there has never been any flooding, even though it is adjacent to the Ciwulan river (fig. 4) which often overflows during heavy rains.



Site plan of Naga village	*Imah panggung* in Naga village

Figure 3. Site plan and *imah panggung* in Naga village

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C. Comparative Study Conclusion

The comparative study of the *imah panggung* in Baduy village and Naga village resulted in several important things namely: (1) The principle of building stilts (*panggung*) can be used as inspiration, ideas, concepts, and house designs that are friendly to flood disasters; (2) The abundant natural potential as environmentally friendly materials; (3) The use of typical house roof forms, such as *sulah nyanda*, *julang ngapak*, and *jolopong*; (4) The contours of the land are not flat as site assets that can be adapted; (5) *Umpak* or *tatapakan* (foundation) from stone as a substructure component as well as a basis for strength; (6) The height of the *kolong* (empty space) under the floor is adapted as needed; (7) Classification of space which consists of three: *Hareup imah* (front or terrace) functions as a building face; *Tengah imah* (living room) serves as the center of activity; *Pawon* (kitchen) functions as service rooms.

D. Imah Panggung as Flood-Friendly House Ideas

The idea of a *imah panggung* as a flood-friendly house is grouped into four parts, namely (1) Site and river boundaries; (2) House plans; (3) Façade and typology of the roof; (4) Structure and construction. Site and river boundary line or *garis sempadan bangunan* (GSS) relating to compaction or zoning (fig. 4) include: (1) Arrangement of building mass such as houses, places of worship, offices, etc. must be in a river border-radius of more than 100 meters from the river bank; (2) The grouping of building functions is arranged regularly so as not to mix, starting from the general function (public area), private function (private area), and service function (service area). The service function is positioned at the rear with a GSS of more than 100 meters, consisting of water ditches, septic tanks, latrines (toilets), and so on. Public functions are placed at the front as the entrance as well as the storefront for the village, such as schools, places of worship, health centers, offices, and others (fig. 4). Meanwhile, the private function as the core of the settlement is in the middle between public functions and services so that it is more protected from various disturbances; (3) Settlement sites and buildings must be on a higher contour than the river water level, both in normal and high tide conditions; (4) Placing the building masses must be spaced apart so that they do not stick together ± 150-200 cm to have more freedom of activities.

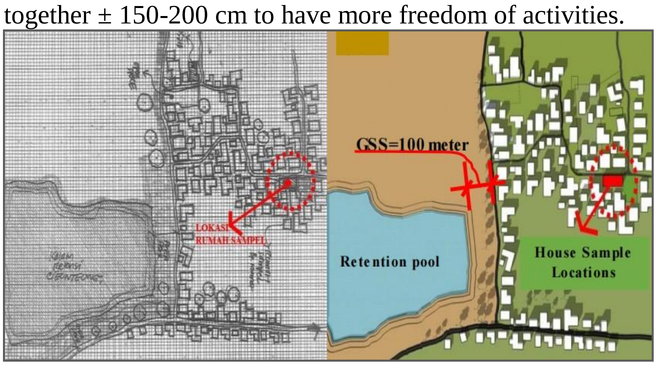

Figure 4. Setting the layout of the building mass in Cieunteung

GSS rules have been established by government regulations (PP) 38 of 2011 and the Minister of Public Works Regulation Republic of Indonesia No: 63 of 1993 as an effort to avoid flooding by creating a flood plan area in the affected area with a flood proofing system based on the radius of the flood from the river bank. Floodproofing is designed in the form of adjusting the height of the building from the ground. The building floor height of ± 0.00 (ground level) inundation must be more than 30-50 cm from the previous flood height. Meanwhile, according to the regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia No: 28/PRT/M/2015 that GSS = 15 meters for rivers with a depth of more than 3-20 meters.

Plan ideas (fig. 5) must be adapted to the needs of the community which are divided into two floors: (1) First floor (bottom) functions for water traffic in the event of a flood. This floor can also be used for selling (shops). Columns or poles are arranged according to the space module with a height of 350 cm; (2) Second floor (top) is the main area of activity, such as sleeping, cooking, eating, and chatting. This floor consists of a bedroom, toilet, common room and kitchen. The floor height is between 3.50-4.00 meters, while the ceiling is partially open. The open ceiling is used as a mezzanine or splits the floor as a santay (relax) area. Access from the first floor to the second floor using stairs that can be closed and opened (folding stairs). The space module uses dimensions of 2 x 2 meters and is made typical (fig. 5). In one corner the module is used for vermiculture or hanging potted plants to neutralize the air to keep it good. At the front of the left corner is provided a manual lift for parents and disabilities that are moved by levers and pendants.

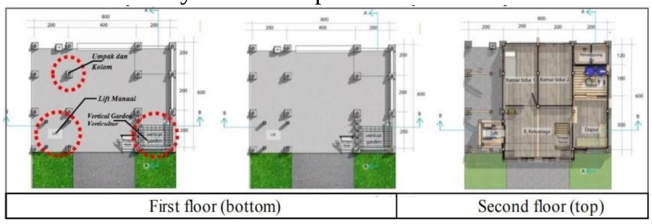

Figure 5. Flood-friendly house design plans in Cieunteung village

The ideas on the facades (fig. 6) and the typology of the roofs of the houses adopt the *imah panggung* architecture of the Sundanese people in Baduy village and Naga village. The choice of this form is because the *imah panggung* architecture has the potential for the beauty of the roof which (maybe) is not found in other architectures. The unique names of the roofs give a flood-friendly house a special character so that it will attract the attention of tourists. The basic shape appears to be a rectangle (*pasagi*) to make it look precise and sturdy, while the roof typology uses the type of *julang ngapak* with additional *sorondoy* (additional) on both sides to make it wider (free). The *julang ngapak* is a form of a gable roof with the left and right wings extended (fig. 6). The shape of this roof also resembles the wings of a flying eagle [22].

Figure 6. Front, back, and side elevation of flood-friendly in Cieunteung

The ideas of structure and construction (fig. 7) relate to systems of strength and material use. The structure and construction of the house are based on *umpak* (foundation), *pangadeg* (wall and floor), and *suhunan* (roof). Building materials can be combined with fabrication, according to ability. The connection can use fabricated materials, such as nails, bolts, or a combination with *paseuk* (pegs) and *beungkeut* (fibers or rattan ties). Natural materials can reduce heat so that the air in the house remains cool and comfortable [23]. On the *umpak*, a wooden pole is placed as the main structure to support the floor. The columns are connected by beams with modules of 2 x 2 meters, while the dimensions are 20 x 20 cm. The walls and floors of the house are composed of column frames and a combination of bamboo beams which are made modular. Wallcoverings are made of planks, bamboo, multiplex, and GRC (lightweight concrete), while floor coverings are made of planks, bamboo, bondex plates, and others [24].

Mockup or miniature as a design model of a flood-friendly house in Cieunteung village shows its true form using a scale (fig. 7). This miniature was made to be shown to the flood victims so that they see the model, so they have an estimate, including costs (real cost estimate). This miniature displays a real form representing the actual form. The appearance of the shape can be seen from various directions, so it is easy to understand (*drawing* 8). In addition to miniatures, researchers also made mockups of the skeletal structure of the horses using scales. The purpose of mockup horses is to help people understand the strength structure of the roof in a flood-friendly house.

Figure 7. Roof frame structure-construction details and flood-friendly house models

VI. CONCLUSION

The advanced technology that has been a symbol of world civilization, including modern architecture, has not yet been fully used as a flood-friendly home solution. Some people in urban areas view modern architecture (considered) to be stronger and more powerful, while traditional architecture is (considered) old school and out of date. This assumption is incorrect because it turns out that traditional architecture is more adaptive and sustainable in addressing problems including flooding. *Imah panggung* with an under system is an alternative solution that is friendly to floods. This study answers the problem of *imah panggung* as flood-friendly house ideas in Cieunteung village, Bandung regency, West Java province, including the ingredients, craftsmanship, and technology.

The conclusion of this study is based on field data analysis, obtained several important things, that it turns out that the *imah panggung* in the traditional architecture of Baduy village and Naga village is very relevant to be used as flood-friendly house ideas. Craftsmanship and architectural technology of the *imah panggung* can be seen in four aspects: (1) The technology of building materials entirely uses natural resources that are environmentally friendly, easier, and cheaper; (2) The technology of *kolong* provides a feeling of warmth at night and coolness during the day. Air circulation that flows well from outside to inside and vice versa provides

ISBN: 978-93-90214-19-8

benefits without having to spend money; (3) The technology of *sengkedan* or *terasering* on the land protects houses from floods and landslides; (4) The technology of the *panggung* in the house turns out to make it easier to be assembled or moved (knock-down), making it more effective and efficient; (5) The unique typology of the roof of the *imah panggung*, among others: the *julang ngapak*, *jolopong*, and *capit gunting* attracts visitors; (6) Craftsmanship in the process of establishing a *imah panggung* is entirely done manually. In practice, modern tools may be assisted according to their abilities. In a conclusion, the *imah panggung* can be used as a prototype for flood-friendly houses in all regions of West Java province.

ACKNOWLEDGMENT

The author expresses his deepest gratitude to various parties who have contributed to this research, such as *Kuncen*, *Pu'un*, *sesepuh*, *dulah*, *tukang*, respondents, informants, and residents of Baduy village and Naga village; Promoter, Co-Promoter 1 and 2, examiners of the Dissertation Qualification Examination; University Leaders, Deans, and Coordinator of the Doctoral Engineering Science Program Study, Udayana University, Bali; University Leaders, Deans, Head of Department and Study Program of Architecture Indonesia University of Education, and all lecturer. It would be in vain without their help until this research finds the answer and its meaning.

REFERENCES

[1] N. Nurulliah, "Jawa Barat Tempati Urutan Kedua Bencana Terbanyak Awal Tahun 2020," in *Harian Umum Pikiran Rakyat*, ed. Bandung: Pikiran Rakyat, 2020.

[2] L. Kurniawan, S. Triutomo, R. Yunus, M. R. Amri, and A. A. Hantyanto, D. Ruswandi, Ed. *Indeks Risiko Bencana Indonesia (IRBI), Badan Nasional Penganggulangan Bencana (BNPB) Indonesia*, Edisi Pertama ed. Citeureup, Sentul: Direktorat Pengurangan Risiko Bencana Deputi Bidang Pencegahan dan Kesiapsiagaan, 2013.

[3] S.A. Paturusi, "Segregasi Ruang Sosial Antara Pendatang dengan Penduduk Asli pada Permukiman Perkotaan di Denpasar". *Jurnal Kajian Bali (Journal of Bali Studies), 6*(2), 57-78, 2016.

[4] A. Rosyidie, "Banjir: Fakta dan Dampaknya, serta Pengaruh dari Perubahan Guna Lahan," (in Indonesia), *Jurnal Perencanaan Wilayah dan Kota, Sekolah Arsitektur Perencanaan dan Pengembangan Kebijakan, Institut Teknologi, Bandung,* Mitigasi Bencana vol. 24, no. 4, pp. 241-249, 2013.

[5] K. Adimihardja and P. Salura, A. Holid, Ed. *Arsitektur dalam Bingkai Kebudayaan*, Edisi Pertama ed. Bandung: CV. Architecture & Communication; FORIS Publishing, 2004.

[6] J. Soemardjo, *Estetika Paradoks*, Edisi Pertama ed. Bandung: Sunan Ambu Press, STISI Bandung, 2006.

[7] A. S. Suhamihardja, *Organisasi dan Struktur Sosial Masyarakat Sunda dan Agama, Kepercayaan, dan Sistem Pengetahuan dalam Masyarakat Sunda dan Kebudayaannya*, Edisi Pertama ed. Bandung: Girimukti Pasaka, Bandung, Jawa Barat, 1984.

[8] W. J. S. Poerwadarminta, "Kamus Besar Bahasa Indonesia," in *Kamus Besar Bahasa Indonesia*, 3 ed. Jakarta, Indonesia: Balai Pustaka, Indonesia, 1991.

[9] M. J. Echols and H. Shadily, in *Kamus Inggris Indonesia. Jakarta: PT Gramedia Pustaka Utama*, ed. Jakarta: PT Gramedia, Jakarta, 2014.

[10] H. Frick and B. Suskiyatno, *Dasar-dasar Arsitektur Ekologis*, Edisi Pertama ed. (Eko-arsitektur 1). Kanisius, Yogyakarta, 2007

[11] I Made Adhika and N.K.A. Dwijendra "Selfie Photos Area and Its Implication to Water Availability and Social Culture in Wanagiri Village, Bali Indonesia". *International Journal of Psychosocial Rehabilitation, 24*(4), 2020.

[12] Nuryanto, "Patukangan Wangunan pada Kampung Baduy Tangtu di Kabupaten Lebak Provinsi Banten," S3-Doktor Draft Proposal Disertasi (Bahan Ujian Proposal), Program Studi Doktor Ilmu Teknik, Universitas Udayana, Bali-Indonesia, Bali, Indonesia, 2020.

[13] Rusman, D. Kurniawan, and C. Riyana, *Teknologi Informasi dan Komunikasi: Mengembangkan Profesionalitas Guru*. Bandung: PT RajaGrafindo Persada, Depok, 2011.

[14] J. L. Havery, "Information Systems: Theory and Practice," ed: Yourdon Press. Prentice Hall, 2009.

[15] M. Z. Wahyudi, "Masyarakat tak Terbiasa Berpikir Rasional," in *KOMPAS.com*, ed. Jakarta, Indonesia: KOMPAS, 2013.

[16] A. Habib, "Ilmu Teknik secara Epistemologi," in *Ilmu adalah hikmah yang tercecer, carilah dan milikilah, meskipun jauh dan menjenuhkan* vol. 2011, ed. Yogyakarta, Indonesia: Blogspot.com, 2011.

[17] J. Zeisel, *Inquiry by design: Tools for environment-behaviour research* (no. 5). CUP archive, 1984.

[18] C. R. Semiawan, *Metode penelitian kualitatif*. Grasindo, 2010.

[19] Nuryanto, Anwar, Ed. *Arsitektur Tradisional Sunda: Pengantar Arsitektur Kampung dan Rumah Panggung*, Edisi Pertama ed. Depok, Jawa Barat: PT. RajaGrafindo Persada, Depok, 2019.

[20] J. K. Garna, Koentjaraningrat, Ed. *Masyarakat Baduy di Banten: Masyarakat Terasing di Indonesia*, Edisi Pertama ed. Jakarta: PT. Gramedia Pustaka Utama bekerjasama dengan Departemen Sosial RI, Dewan Nasional Indonesia untuk Kesejahteraan Sosial, 1993.

[21] K. Adimihardja, "Orang Baduy di Banten Selatan: Manusia Air Pemelihara Sungai, Jakarta," (in Indonesia), *Jurnal Antropologi Indonesia. FISIP UI. Halaman*, Antropologi vol. 57, pp. 47-59, 2000.

[22] I. Hermawan, "Bangunan Tradisional Kampung Naga: Bentuk Kearifan Warisan Leluhur Masyarakat Sunda," *SOSIO-DIDAKTIKA: Social Science Education Journal,* vol. 1, no. 2, pp. 141-150, 2014.

[23] N.K.A. Dwijendra "*Arsitektur & Kebudayaan Bali Kuno*" Kerjasama CV. Bali Media Adhikarsa [dan] Udayana University Press, 2009.

[24] M. Gartiwa, "Modus Adaptasi Klimatik pada Arsitektur Vernakular Masyarakat Kampung Cikeusik Desa Kanekes

Kabupaten Lebak Provinsi Banten," Disertasi Doktor Arsitektur, Program Studi Doktor Arsitektur SAPPK ITB, Institut Teknologi Bandung, Bandung, 2017.

[25] A. Harapan, "Sistem Sambungan Konstruksi Rumah Tradisional di Kampung Pulo, Jawa Barat," (in Indonesia), *Jurnal Arsitektur ARCADE,* vol. 2, no. 2, pp. 101-107, 2018.

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Pushover Analysis of Normal Building Comparison with Soft Storey Building at Various Floor Level

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Abstract— ***The new expansion in population and urbanization are getting changes the field of development. The less accessibility of land in metropolitan territories is the significant purposes behind picking soft storey structures. These kinds of structures are not attractive in seismically dynamic territories on the grounds that different vertical anomalies are incited in such structures which have performed reliably poor during calamities. The new encounters acquired from the fiascos say that the constructions are insufficient to meet necessity of codes. Most of structures that fizzled during the catastrophes were of the open ground storey. So an exhibition based present day strategy nonlinear static analysis is picked. Most utilized strategy to discover the exhibition of construction is nonlinear static investigation utilizing PUSHOVER ANALYSIS. The Pushover Analysis measure includes applying loads by utilizing a programing programming (SAP2000) software.***

The current investigation includes Three distinct kinds of structures situated in Zone 5 examined in (SAP 2000) with different viewpoints identified with the exhibition of constructions with soft Storied, with propping and with shear divider. At first RC open casing is considered to comprehend its conduct. Later the comparison of normal R. C. building frame with the soft storey building of various floor level i.e. ground floor, combination of ground and 2nd floor and combination of ground, 2nd and 4th floor. Also determine the deformation and base shear of the above kind of building are compared and result are discussed in details.

Index Terms— ***Soft storey building, Response spectrum, Push over Analysis, SAP 2000.***

I. INTRODUCTION

A soft storey building is one which is a multi-stories working with enormous openings, wide spaces at the ground level which for the most part requires a shear divider for expanding the limit of the structure. Because of the urbanization for the most part, the constructors are selecting soft storey structures where enormous openings are utilized as stopping spaces. Presently a day since they give stopping territory this is generally required. This sort of building shows inclination to fall during calamity due to the soft storey impact. The soft Storey structures are less safe and have less solidness during the hour of debacle. In a design on the off chance that a Storey has solidness under 70%, at that point such constructions are called commonly soft storey structures. The huge spaces present in a design are situated in ground storey and they are utilized for business spaces like shops or for stopping territories. So in such cases if harm happens to the ground storey there is an opportunity for breakdown of the whole design. So shear dividers are by and large utilized during the development of medium and tall structures. They forestall clasping of dividers. The development of soft storey structures requires a lot of care during their planning.

Extreme Soft Storey

An extreme soft storey is the one wherein the horizontal solidness is under 60percent of that in the storey above or then again under 70percent of the normal solidness of the three stories above. There has been increment in the populace from past numerous years. The increment of populace has made numerous issues in metropolitan zones. Lack of land has been the principle issue in metropolitan territories. This prompted the issue of stopping in principle metropolitan urban communities. The accessibility of space has gotten less for stopping so it has prompted the development of soft storey structure. The soft storey is one in which there are openings in the ground floor. The strength of the segments in such constructions is less as floor increments. In the event that the section in that floor is less solid it might cause avoidances that impact the complete strength of the structure. The presence of dividers in the upper floor makes the construction more grounded than an open design. Because of such sort of arrangements, the horizontal relocations of entirety structure is represented generally by the mishapening at the lower stories. In this manner, it is critical to break down the request of power and distortion of the individuals at various pieces of design.

Soft Storey Failure

The disappointment of soft storey is a direct result of the interest of solidarity of the segment in the main storey which is high when contrasted with different floors, in highest level the section powers are diminished because of the presence of block dividers that share the powers and the upper floors are hardened and solid when contrasted with first soft storey. So the sidelong relocation of the construction is available generally at the primary storey of the design. Consequently when the parallel power acting has less solidness it might influence the entire design and the construction may fizzle.

Rc Shear Wall

Reinforced concrete (RC) buildings with RC walls are called as Shear Walls in total to slabs, beams and columns. These walls normally start from the foundation level and are sustained throughout the building height. Shear walls provide more strength and stiffness to buildings that reduces the sway and displacements of the building and reduces damage to structure and its contents.

Cross Bracings

The cross bracings help the structure to give strength because the open ground floor of soft storey structure has no walls that reaction the structure. So they are added to the structure to increase their strength and to reduce the displacements. When compared to shear wall they have less control but also bracings help the structure to build up strength and resist the impairment.

Static Analysis:

Static analysis is again divided into:

- Linear static and
- Non-linear static analysis

A performance based new modern technique

Nonlinear static analysis is chosen which involves

II. Pushover Analysis

The underlying designing's have as of late built up another plan that considers a presentation based construction and are disappearing from streamlined direct flexible strategies towards a more non-straight technique. Pushover examination is an investigation strategy wherein the construction is exposed to expanding horizontal powers with a stature savvy conveyance until an objective uprooting is reached. Fundamentally, a sucker investigation is a progression of steady static examination completed to build up a limit bend for the structure. In view of the limit bend, an objective dislodging which is a gauge of the relocation that the design earthquake will deliver on the structure is determined. The degree of harm experienced by the construction at this objective removal is viewed as illustrative of the harm experienced by the structure when exposed to configuration level ground shaking. Numerous strategies were introduced to apply the nonlinear static weakling (NSP) to structures.

II. METHODOLOGY

1. Design the G+5 Storey building with various condition such as Normal building, Soft storey at ground level, Soft storey at ground and 2nd floor and soft storey at ground, 2nd storey and 4th storey building.

Specification of Building

a. Nature of building:- Normal and soft Storey building
b. No. of Storey of building:- G+5
c. Column size:- 300mm x 300mm
d. Beam size:- 230mm x 300mm
e. Slab Thickness:- 130mm
f. Shear wall thickness:- 230mm
g. Grade of concrete for beam and column:- M20
h. Rebar: HYSD550

2. Application of load pattern as live load, dead load, Earthquake load, Roof load and Push X and Y direction load.
3. After assigning of load pattern, load case to be applied with response spectrum and time history analysis.
4. Then application of hinges to the column and beam with gradual selection of beam and column and make sure that the hinges are applied with a proper manner.
5. Then run the analysis and software shows the result with the various variant of push x and push y analysis.

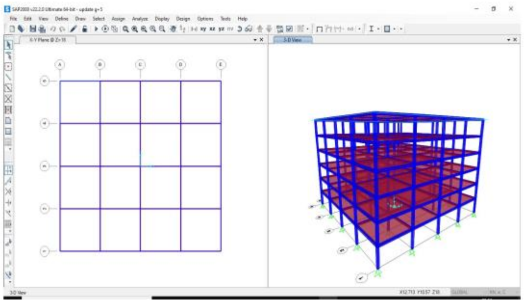

Fig. No.1:- Normal Building

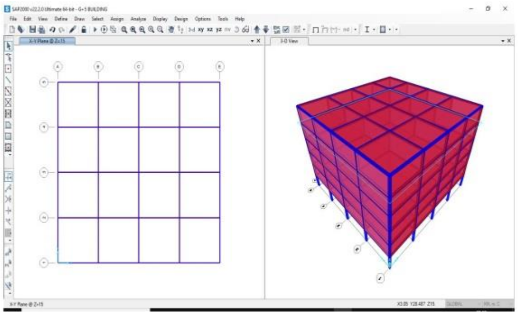

Fig. No. 2:- Ground Floor as a Soft Storey

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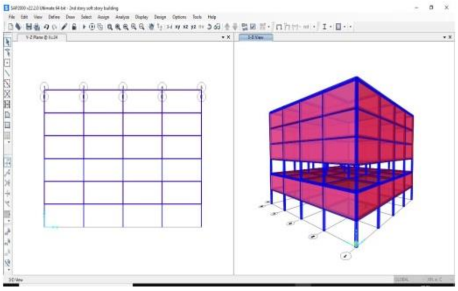


Fig. No. 3:- Ground and 2nd Storey as a Soft Storey

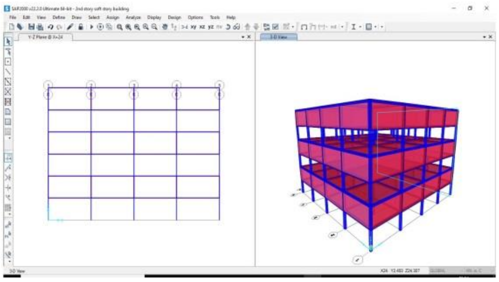
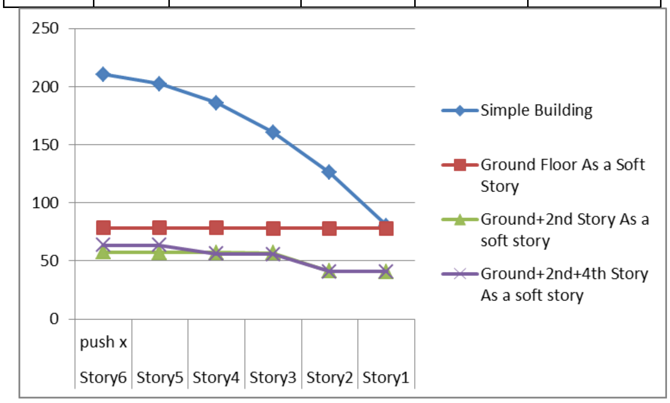


Fig. No. 4:- Ground, 2nd and 4th Floor as a Soft Storey

III. MODEL ANALYSIS

Storey Displacement:-

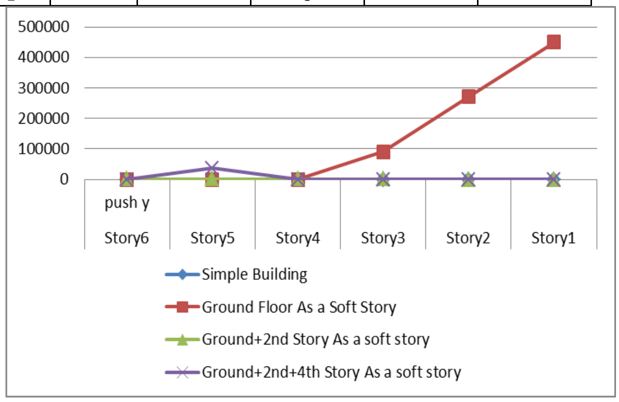
Maximum Storey Displacement By applying PUSH X Load					
		Simple Building	**Ground Floor As a Soft Storey**	**Ground+2nd Storey As a soft Storey**	**Ground+2nd +4th Storey As a soft Storey**
Storey	**Output Case**	**Maximum**	**Maximum**	**Maximum**	**Maximum**
		Mm	**mm**	**mm**	**mm**
Storey6	push x	210.408	78.522	57.471	63.582
Storey5		202.132	78.428	57.335	63.44
Storey4		185.771	78.326	57.192	55.926
Storey3		160.548	78.217	57.032	55.772
Storey2		125.977	78.103	41.096	40.828
Storey1		80.173	77.97	40.954	40.691



Graph No. 1:- Maximum storey Displacement By applying PUSH X Load

storey displacement is occurring due to the application of Push X load. After the analysis of the model by pushover analysis, the displacement occur of the simple building is much higher than that of the other type of building.

Maximum Storey Displacement By applying PUSH Y Load					
		Simple Building	**Ground Floor As a Soft Storey**	**Ground+2nd Storey As a soft Storey**	**Ground+2nd+4th Storey As a soft Storey**
Storey	**Output Case**	**Maximum**	**Maximum**	**Maximum**	**Maximum**
		mm	**mm**	**mm**	**mm**
Storey 6	push y	232.005	107.128	283.027	198.741
Storey 5		222.695	106.693	282.043	36542.055
Storey 4		203.313	106.222	281.009	165.07
Storey 3		173.178	90129.866	279.849	164.399
Storey 2		132.076	270232.9	163.533	98.646
Storey 1		78.488	450335.988	162.511	98.051



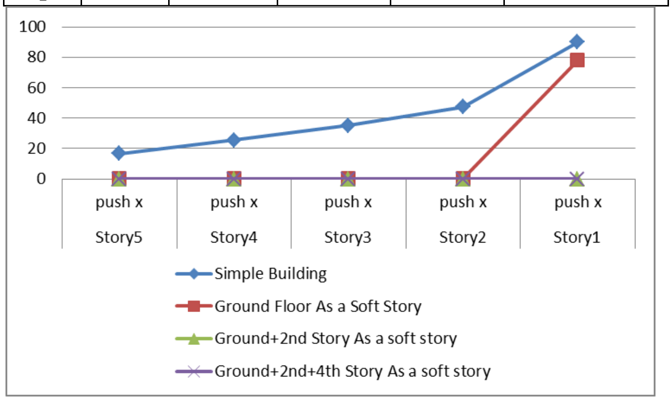
Graph No. 2:- Maximum storey Displacement By applying PUSH Y Load

As per the analysis of the structure, the storey displacement of the ground storey as a soft storey building gives a maximum displacement at a ground level and as the storey rises the displacement goes on decreasing order after the application of PUSH Y Load.

In both of the analysis, the soft storey gives much displacement as compare to the other type of storey.

Storey Drift:-

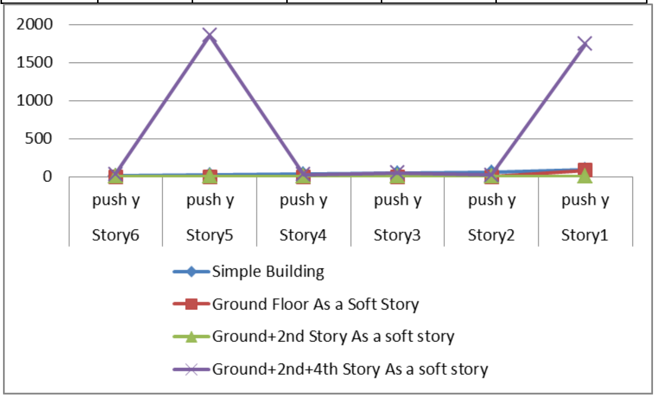
Maximum Storey Drift By applying PUSH X Load					
		Simple Building	**Ground Floor As a Soft Storey**	**Ground+2nd Storey As a soft Storey**	**Ground+2nd+4th Storey As a soft Storey**
Storey	**Output Case**	**Max Drift**	**Max Drift**	**Max Drift**	**Max Drift**
		Mm	**mm**	**mm**	**mm**
Storey 6	push x	8.344	0.095	0.000045	0.000047
Storey 5	push x	16.555	0.102	0.000048	0.002505
Storey 4	push x	25.555	0.11	0.000053	0.000051
Storey 3	push x	35.117	0.114	0.005312	0.004981
Storey 2	push x	47.246	0.134	0.000047	0.000046
Storey 1	push x	89.998	77.97	0.013651	0.013564



Graph No. 3:- Maximum storey Drift By applying PUSH X Load

Maximum Storey drift is found to be 89.998mm at the simple building and less drift are found to be 0.000046mm which is very negligible.

Maximum Storey Drift By applying PUSH Y Load					
		Simple Building	**Ground Floor As a Soft Storey**	**Ground+2nd Storey As a soft Storey**	**Ground+2nd+4th Storey As a soft Storey**
Storey	**Output Case**	**Max Drift**	**Max Drift**	**Max Drift**	**Max Drift**
		Mm	**mm**	**mm**	**mm**
Storey6	push y	9.362	0.436	6.57388	33.492762
Storey5	push y	19.899	0.471	6.573881	1854.577699
Storey4	push y	31.036	0.507	6.573877	27.803103
Storey3	push y	42.417	0.527	5.663569	49.692416
Storey2	push y	56.146	0.614	2.993679	19.995053
Storey1	push y	88.518	85.03	1.851611	1745.073284



Graph No. 4:- Maximum storey Drift By applying PUSH Y Load

The maximum sstorey drift are found to be at that place where the soft storey is found out. In combination of ground, 2nd and 4th storey building has a maximum drift at that place where the soft storey occur.

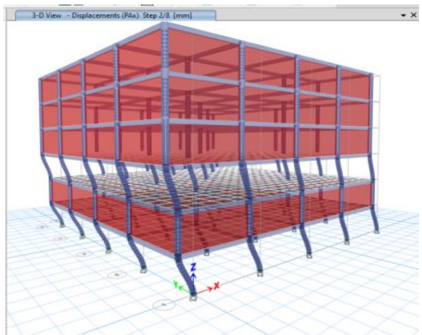


Fig No. 5:- Soft Storey displacement due to application of Pushover load

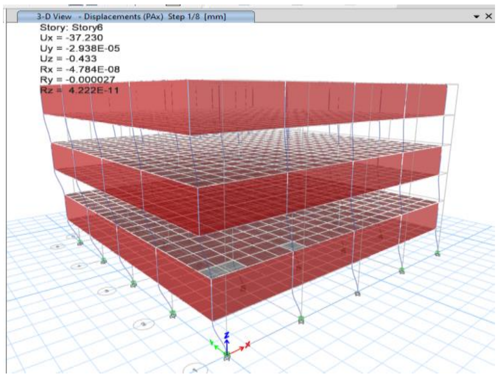


Fig No. 6:- Soft Storey displacement due to application of Pushover load

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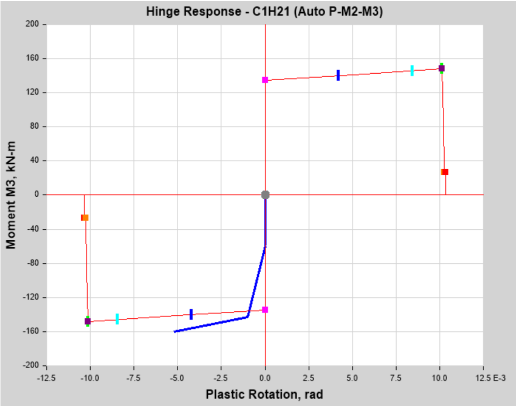
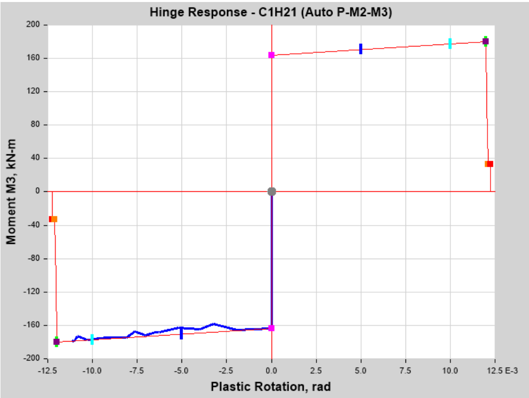
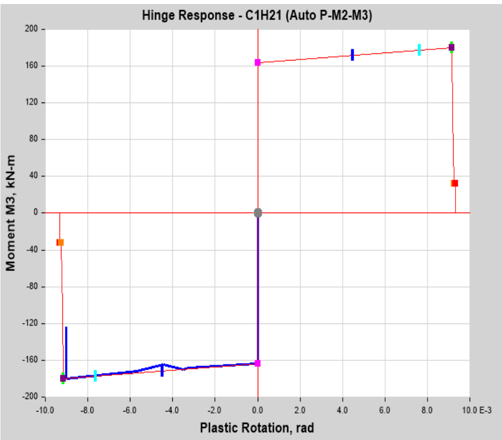
Pushover Behavior of the structure:-



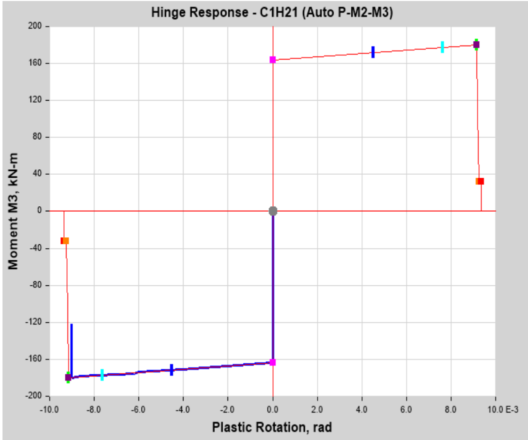
Graph No. 5:- Pushover graph for normal building



Graph No. 6:- Pushover graph for Ground Storey as a soft Storey building



Graph No. 7:- Pushover graph for Ground Storeyand 2nd Storey as a soft Storey building



Graph No. 8:- Pushover graph for Ground Storey, 2nd Storey and 4th Storey as a soft Storey building

In this above structure, the whole building structure follows the hinge response with the plastic rotation. But in case of simple building, it is observed that building does not follow pushover analysis graph as it reaches to the LS Level.

IV. CONCLUSION

1. The storey displacement is much greater in simple building when the pushover load is applied and less in combination of ground and 2nd storey building.
2. The storey drift is occurring due to the application of loading. As the displacement and the drift is nearly similar to each other. The storey drift is found to be maximum at simple building structure and minimum at the combination of Ground and 2nd storey as a soft storey building.
3. Reference pushover curve has a various different level and it gives proper behavior of a building after the application of the load. In simple building all the joints shows IO level of the graph and the combination of Ground and 2nd storey as a soft storey gives emergency level at some point.
4. As per the result concluded that soft storey gives better results than simple building but it will not prove that which soft storey is suitable.

REFERENCES

1. Amin.M.R, Hasan.P, Islam.B.K.M.A, (2011), ”Effect of soft storey on multistoried reinforced concrete building frame
2. Haroon Rasheed Tamboli, Umesh.N.Karadi, (2012) Seismic Analysis of RC Frame Structure with and without Masonry Infill Walls
3. IS 1893 (Part 1)-2002, Criteria for Earthquake Resistant Design Of Structures

ISBN: 978-93-90214-19-8

4. Karwar1.D.B, Londhe. R.S, (2014), a performance of RC framed structure using pushover analysis
5. Lamb.P.B, R.S.Londhe (2012), Seismic behavior of soft first storey
6. Munde P.K, Magarpatil H.R, (2012), Seismic Response of RC Framed Masonry InfilledBuildings with Soft First Storey
7. NF Ukey, V Varghese, BS Ruprai (2014) "An overview of seismic and wind loading effect on G+ 11 building" AIP Conference Proceedings 2104 (1), 020051.
8. Priyanka Hanamantrao Jagadale, SuchitraHirde, (2015) Seismic Performance of Multi- storied Reinforced Concrete Building with Soft Storey (2015)
9. Rahul D Patil, A Siddique, M Ghate, J Motghare, S Hadk, B S Ruprai "An overview on seismic Analysis of multistoried building using Equivalent Static Load Method and Response Spectrum Method : A Literature Review," international Conference on Innovative Realms in Civil Engineering (IRICE-2018) 24-25 Jan 2018 ISBN:97881-935941-1-7.

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A Critical Review on Mechanical and Thermal Buckling of Functionally Graded Plates

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Abstract— Functionally Graded Materials (FGMs) are the advanced materials in the family of engineering composites that are developed to tailor the material architecture at microscopic scales to optimize certain functional properties of the structure. The study on behaviour of FGM plates under thermal loadings has become attractive and hence significant investigations are carried out in recent decades to predict the response of FGM plates subjected to thermal loadings. This paper presents a critical review on the various literature dealing with the study on the mechanical and thermal buckling of FGM plates. In addition to this, an attempt has been made to discuss the types, applications, manufacturing techniques and different mathematical idealization techniques of FGMs. An effort has been made to include all the important contributions made by the researchers in the current area of interest. This review is intended to give a detailed information on graded composites to the readers for taking future directions of research in this area. Finally, a brief conclusion is presented incorporating future research needs for the successful implementation of FGM in design.

Index Terms—*Functionally Graded Materials, Mathematical Idealization Techniques, Mechanical buckling, Thermal buckling.*

I. Introduction

Materials, energy and modern science are the three pillars of the modern technology. New material developments and research are leading the invention of materials, as the cornerstone of the 21st century high - tech field. In recent years, materials science has gained rapid development. The reason is the increased inter - disciplinary interactions as one hand and the introduction of cross - penetration of new theories, new methods and new experimental techniques on the other hand. Also, the urgent need for practical application of the material has put forward new demands.

Functionally graded materials (FGMs) are advanced high performance, heat resistant materials being able to withstand ultra-high and extremely large temperature gradients. FGMs are microscopically inhomogeneous in which the mechanical properties vary smoothly and continuously from one surface to the other. This is achieved by gradually varying the volume fraction of the constituent materials. The special characteristics of FGMs, which are usually, made of metal and ceramic make them preferable to the conventional composite materials which are subject to delamination, for engineering applications.

A functionally graded material (FGM) is a two-component composite characterised by a compositional gradient from one component to the other[1]. In contrast, traditional composites are homogeneous mixtures, and they therefore involve a compromise between the desirable properties of the component materials. Since significant proportions of an FGM contain the pure form of each component, the need for compromise is eliminated. The properties of both components can be fully utilised. For example, the toughness of a metal can be mated with the refractoriness of a ceramic, without any compromise in the toughness of the metal side or the refractoriness of the ceramic side.

In the simplest FGMs, two different material ingredients change gradually from one to the other. Discontinuous changes such as a stepwise gradation of the material ingredients can also be considered as an FGM. The most familiar FGM is compositionally graded from a refractory ceramic to a metal. Typically, FGMs are made from a mixture of ceramic and metal or a combination of different materials. The ceramic in an FGM offers thermal barrier effects and protects the metal from corrosion and oxidation, and the FGM is toughened and strengthened by the metallic composition. Functionally Graded Materials (FGMs) have attracted much attention as advanced structural materials in many structural members used in situations where large temperature gradients are encountered. FGMs are designed so that material properties vary smoothly and continuously through the thickness direction from the surface of a ceramic exposed to high temperature to that of a metal on the other surface. The continuity of material properties reduces the influence of the presence of interfaces and avoids high interfacial stresses. Due to above unique properties, this class of material survives the environment with high temperature gradients keeping desired structural integrity to achieve target performance in terms of optimum response with respect to thermal and mechanical loading[2]. The concept of FGM, initially developed for super heat resistant materials to be used in space planes or nuclear fusion reactors, is now of interest to designers of functional materials for energy conversion, dental and orthopaedic implants, sensors and thermo-generators and wear resistant coatings.

II. History

The concept of FGM was first considered in Japan in 1984 during a space plane project, where a combination of materials used had served the purpose of a thermal barrier capable of withstanding a surface temperature of 2000 K and a temperature gradient of 1000K across a 10 mm section. In recent years this concept has become more popular in Europe, particularly in Germany[3]. The FGM is a compositematerial whose composition varies according to the required performances. By gradually varying the volume fractions of the constituents, the mechanical properties of FGM exhibit a smooth transition, thus distinguishing them from laminated composite materials, which have a mismatch of mechanical properties across interface due to two discrete materials bonded together.

III. Types Of FGM

At the inception of the development of the FGMs, the concept was to remove the sharp interface that existed in the traditional composite material, and to replace it with the gradually changing interface, which was translated into the changing chemical composition of this composite at this interface region. The growing interest of FGMs in different areas has resulted in the development of various FGMs. The developed FGMs have varied mechanical, electrical, chemical and magnetic properties depending on their applications[4][5]. The different types of FGMs that are being produced now include the chemical composition gradient FGM, the porosity gradient FGM, and the microstructural gradient FGM. Each of these types of FGMs is discussed in detail in the following sections.

A. Chemical Composition Gradient Functionally Graded Materials

This is the type of functionally graded materials, where the chemical composition is gradually varied, according to the spatial position in the material. This could be in the form of a single phase, or in a multiphase material. A single-phase FGM is produced when the composite is produced from a single phase, as a result of the solubility of the chemical elements of one phase in the other phase. This usually occurs during the sintering process. The gradual change in the distribution of the chemical elements in the single-phase results in the formation of the FGM. According to the phase diagram and thermodynamic limitations, when some materials are added to another material, the material that was added to the other material would be soluble in that material over a range of composition and mixing conditions. Such material would become what is called a single-phase material but with a varying chemical composition because of the solubility [5]. This type of FGM is less common. The most commonly designed and most commonly used FGMs are the ones with a multiphase chemical composition.

B. Porosity Gradient Functionally Graded Materials

The porosity gradient functionally graded material is another type of FGM, in which the porosity in the material is made to change with the change in the spatial position in the bulk material. The shape and size of the pore are designed and varied, according to the required properties of the FGM. Porosity gradient materials could be porosity density gradation or pore size gradation. The porosity density is produced with the density of porosity changing with respect to the spatial position across the volume of the material. The pore size gradient of the FGM, on the other hand, is produced by varying the pore sizes or the pore shape, or both. The function of pore size gradation is seen in bone implants, where the larger pore sizes in the porosity functionally graded implants are to be implanted in the bone, in order to aid the bone ingrowths, while the smaller pores are useful for the cartilage growth. The function of porosity - graded FGM includes the gradual change in the pore distribution in a porosity-graded FGM that helps in absorbing the shock from one face to the other. It also helps to provide thermal insulation; it helps to aid the catalytic efficiency; and it also helps to relax the electrical and the thermal stresses. The porosity gradient in an FGM also has an effect on the tensile strength and the Young's modulus of the material.

C. Microstructure Gradient of Functionally Graded Materials

Microstructural gradient functionally graded material is another type of FGM, where the microstructure is tailored so that different microstructures are produced in the material, which is made to change gradually, so as to achieve the required properties from the material. Microstructural gradation can be achieved during the solidification process, such that the surface of the material is quenched, for example, when producing a very hard surface property of the material. The core of the same material is allowed to cool down slowly, which would help to produce different microstructures from those on the surface of the material to the innermost part. Also, the microstructural gradation can be achieved through a controlled heat treatment process. For example, a varying microstructure can be produced by a controlled heat treatment of a titanium-alloy cylindrical part.

IV. Fabrication Processes

The functional change of FGMs can be realized by the compositional change according to the functional design [6]. There are many kinds of processes applied to FGM fabrication. The processes are classified into three based on the starting materials: gaseous processes, liquid processes, and solid processes.

A. Chemical Vapour Deposition (CVD)

B. Physical Vapour Deposition(PVD)

C. Plasma Spraying Process

D. Surface reaction process

ISBN: 978-93-90214-19-8

E. Electrodeposition Process

F. Centrifugal; casting process

G. Powder metallurgy process

H. Spark Plasma Sintering Process

V. APPLICATION OF FGM

FGMs have great potential in applications where the operating conditions are severe, including spacecraft heat shields, heat exchanger tubes, biomedical implants, flywheels, and plasma facings for fusion reactors, etc. Various combinations of the ordinarily incompatible functions can be implemented to create new materials for aerospace, chemical plants, nuclear energy reactors, etc. For example, a discrete layer of ceramic material is bonded to a metallic structure in a conventional thermal barrier coating for high temperature applications[7][8]. However, the abrupt transition in material properties across the interface between distinct materials can cause large inter-laminar stresses and lead to plastic deformation or cracking. These harmful effects can be eased by smooth spatial grading of the material constituents. In such cases, large concentrations of ceramic material are placed at corrosive, high temperature locations, while large concentrations of metal are placed at regions where mechanical properties need to be high.

The concept of FGMs has been successfully applied in thermal barrier coatings where requirements are aimed to improve thermal, oxidation and corrosion resistance. FGMs can also find application in the communication and information techniques. Abrasive tools for metal and stone cutting are other important examples where gradation of surface layer has improved performance.

VI. MATHEMATICAL IDEALIZATION TECHNIQUES

The fabrication of the FGMs can be considered by mixing two discrete phases of materials, for example, a distinct mixture of a metal and a ceramic. The effective material properties, viz. elastic moduli, shear moduli, density, etc. of the graded composites are being evaluated based only on the volume fraction distribution and the approximate shape of the dispersed phase. Several micromechanics models have been developed over the years to infer the effective properties of macroscopically homogeneous composite materials. The analytical approaches, both finite element methods and micromechanical models are frequently used for FGM modelling. The effective material properties like Young's modulus, Poisson's ratio, coefficient of thermal expansion, and thermal conductivity on the upper and lower surfaces are different but are predefined[9]-[12].

However, Young's modulus, coefficient of thermal expansion and thermal conductivity of the plates vary continuously only in the thickness direction (Z-axis as shown in Fig. 1.7); that is, $E=E(z)$, $\nu=\nu(z)$, $k=k(z)$. The FGM plate of thickness "h" is modelled usually with one side of the material as ceramic and the other side as metal. The "z" is varying from "h/2" at top face, "0" at the middle of the thickness, to "−h/2" at bottom face. However, material properties in the thickness direction of the FGM plates vary with power law functions, sigmoid functions or exponential functions. A mixture of the two materials composes the characteristics through the thickness direction.

VII. THERMO-MECHANICAL BUCKLING OF FG PLATES

When FGMs are exposed to high temperature fields, their structural integrity will be lost and becomes geometrically unstable. Buckling is a stability state of a structural element, at which the stable flat equilibrium configuration of the plate begins to deform and starts bending. This in-plane thermal load which creates instability in the structure is called critical buckling temperature. When this temperature is further increased, the growth of deflections and stresses will accelerate and eventually leads to failure of the structure. Zenkour [13] conducted the free vibration and buckling analysis of simply supported FGM sandwich plates using Classical Plate Theory (CPT), First Order Shear Deformation Theory (FSDT), Third-order Shear Deformation Theory (TSDT) and Sinusoidal Shear Deformation Theory (SSDT). They studied the effect of transverse shear deformations, plate aspect ratio, side-to-thickness ratio and volume fraction distributions. The effect of core thickness relative to the total thickness of the plate on the critical buckling load and the eigen frequencies were also investigated. Samsam Shariat et al. [14] developed closed form solutions for the buckling loads based on TSDT on simply supported FG plates. Both the mechanical and thermal loadings were varied throughout the thickness directions. Samsam Shariat et al. [15] investigated the influence of geometrical imperfections on thermal instability of FG plates. CPT in conjunction with power law function was used to develop the fixed-simply supported FG plate. The thermal loads were assumed to be uniform, non-linear and axial temperature variation along the x-direction of FG plate. Serge Abrate [16] conducted a study on the variation of elastic properties through the thickness of FG plate. They derived the conditions for uncoupling the equations of motion and was shown that for both isotropic and orthotropic FG plates, it is always possible to select a reference plane so that the equations become uncoupled. Thus isotropic FG plates behave like homogenous isotropic plates and orthotropic plates behave like homogenous orthotropic plates which means they are governed by the same equations. Ganapathi et al. [17] used FSDT in conjunction with finite element approach to analyse the thermal buckling behaviour of simply supported FGM skew

ISBN: 978-93-90214-19-8

plates. A non-uniform temperature field was assumed to vary only in the thickness direction of plate and is evaluated using the heat conduction equation. They studied the influence of thickness and aspect ratios and skew angle on the thermal stability strength of FG skew plates. Lee et al. [18] carried out the post-buckling analysis of FG plates subjected to edge compression and thermal conditions based on the FSDT and the von Karman relationship. The effective material properties of the FG plates were varied in accordance with power-law distribution. A set of mesh-free kernel particle functions were used for approximating the displacement fields. To eliminate the membrane and shear locking effects for thin plates, these terms were evaluated using a direct nodal integration technique. The effects of the volume fraction exponent, boundary conditions and temperature distribution on post-buckling behavior are examined in this paper. Ghannadpour et al. [19] developed finite strip method for analysing buckling behaviour of FGP under thermal loadings. The solution was obtained by the minimization of total potential energy and solving corresponding eigen value problem. The harmonic functions were used in the longitudinal direction and quartic Lagrange- Hermite interpolation function was used in the transverse direction. Different boundary conditions were used to discuss the effect of geometrical parameters and material properties on the buckling temperature difference of FGM plates. Bouazza et al. [20] investigated the buckling of simply supported FG plate subjected to uniform and linear temperature rise through the thickness based on the FOST and applying the von Karman type stability and compatibility equations. They observed in their study that transverse shear deformation has considerable effects on the critical buckling temperature of FG plate, especially for a thick plate or a plate with large aspect ratio. Ramu et al. [21] used the Finite Element Method for modelling and buckling analysis of FGM plate. The uniaxial and biaxial compression loads along with simply supported boundary conditions on rectangular FGM were investigated. The effect of different loading conditions, boundary conditions, aspect ratios and power law index on FG plates were also investigated. Ovesy et al. [22] developed a semi-analytical finite strip method for analysing the post buckling behaviour of functionally graded rectangular plates in thermal environments where plates are under uniform, tent-like or non-linear temperature change across the thickness. Thang [23] investigated the thermal buckling behaviour of imperfect rectangular plates with FG coatings under uniform temperature rise. Theoretical formulations are based on the Classical plate theory along with Von-Karman nonlinear kinematic relations. The response of FG plates were investigated by varying power law index, imperfections, geometric parameters and temperature distributions. Raki et al. [24] derived the equilibrium and stability equations of a rectangular FGM plate under thermal loads based on higher order shear deformation theory. The derived equations were similar to that of laminated composite plate with 50 layers. Kolakowski et al. [25] studied the stability of the square step variable gradation in-plane plate simply supported along the whole circumference under simultaneous compression and shear load.

VIII. Mechanical buckling of FG plates

Birman [26] was the first person who attempted to solve the buckling problem of FGM hybrid composite plates. Results were presented for the critical buckling load of FGM hybrid composite plates made of 3 different types of fibres viz., Silicon Carbide, Boron and Nicalon fibres. It was illustrated from the results that the buckling loads can be significantly increased by using piecewise reinforcement of fibres in composite plates. The elastic bifurcation buckling of FGM plates with nonuniformly distributed fibres under uniaxial compressive loading was studied by Feldman and Aboudi [27] who combined micromechanical and structural approach. An improvement in buckling load up to 100% as compared to the corresponding uniformly reinforced structure was presented. Ma and Wang [28] established the TSDT plate solution of the axisymmetric bending and buckling of FGM circular plates in terms of the CPT solutions of isotropic circular plates. The TSDT solutions were compared with those obtained using FSDT and CPT to show that FSDT is enough to consider the effect of shear deformation on the axisymmetric bending and buckling of FGM plates. Zenkour [29] used the SSDT to study the buckling and free vibration of simply-supported FGM sandwich plates. The obtained results were validated by comparing with those obtained using CPT, FSDT and TSDT. The critical buckling load obtained using nonsymmetric FGM plates was found to be higher than those of symmetric counterparts. Aydogdu [30] investigated the conditions for the bifurcation buckling of FGM plates based on the CPT. It was demonstrated that, bending moment is required to keep the simply-supported plates in flat under in-plane loading whereas, clamped plates can provide flatness before buckling. Saidi et. al. [31] studied the axisymmetric bending and buckling using the UTST. In addition, relationships between the UTST solutions for thick FGM circular plates and the CPT solutions of homogeneous thin plates were also presented for the axisymmetric bending and buckling. It was observed that UTST results were much closer to TSDT results than FSDT ones when bending analysis is considered. Mohammadi et al. [32] presented the Levy solution using the principle of minimum potential energy for the buckling analysis of thin FGM plates based on the CPT subjected to different mechanical loads under various boundary conditions. A new refined hyperbolic shear deformation theory was presented by Meiche et al. [33] using the Navier's

ISBN: 978-93-90214-19-8

solution technique for the buckling and free vibration analyses of FGM sandwich plates. The obtained results were validated by comparing with those obtained using CPT, FSDT, parabolic shear deformation theory, SSDT and 3D elasticity theory. Thai and Choi [34] extended the refined theory proposed by Shimpi for the buckling analysis of FGM plates subjected to in-plane loading. The theory was found to have strong similarity with CPT in many aspects which can account for quadratic variation of the transverse shear strains across the thickness and satisfies the zero traction boundary conditions on the top and bottom surfaces of the plate without using shear correction factors. The accuracy of the results obtained was demonstrated by comparing them with those of CPT, FSDT and TSDT. Latifi et al. [35] used the CPT based on physical neutral surface along with a double Fourier series expansion of displacement functions to investigate the buckling behaviour of FGM plates subjected to proportional biaxial compressive loadings with arbitrary edge supports. A new refined plate theory with four unknowns was used by Fekrar et al. [36]to study the mechanical buckling of FGM plates. Najafizadeh and Eslami [37] presented the buckling analysis of FGM circular plates based on the Love–Kirchhoff hypothesis and the Sander's non-linear strain-displacement relation with either simply-supported or clamped edges subjected to uniform radial compression. It was concluded by the authors that the mechanical instability of FGM plates was lower than fully ceramic plates. A perturbation technique along with one-dimensional differential quadrature approximation and Galerkin procedure was employed by Yang and Shen [38] to investigate the post buckling behaviour of fully clamped FGM rectangular plates based on the CPT under transverse and in-plane loads. The authors have concluded that though the mechanical performance of FGM plates is quite similar to homogeneous isotropic ones, they do exhibit some unique and interesting characteristics due to the grading of material composition. Again Yang et al. [39] extended the same work to study the effect of initial geometric imperfection on the post-buckling behaviour of FGM plates based on the Reddy's TSDT under various boundary conditions. It was concluded that the effect of localimperfection becomes much less as its centre deviates from the centre of the plate. A three nodded shear flexible plate element based on the field-consistency principles was used by Prakash and Ganapathi [40] for the asymmetric flexural vibration analysis of FGM plates based on the FSDT. It was concluded that the non-linear temperature variation through the thickness results in higher critical buckling loads compared to constant through the thickness variation of temperature. Shariat et al. [41] studied the buckling behaviour of geometrically imperfect FGM plates based on the CPT. A closed form solution was presented by Najafizadeh and Heydari [42] for the buckling of FGM circular plates based on the Reddy's TSDT subjected to uniform radial compression. The obtained results were compared with those of CPT and FSDT and it was observed that the buckling values predicted by TSDT were the lowest.

CONCLUSION

Because of the wide material variations and applications of FGMs, literature corresponding to FGMs in the material constituent, fracture mechanics and processing have been rapidly increased in the past few years. A brief review on the progressive developments in the mechanical and thermal buckling analyses of FG plates are presented. Most of the approaches used for the analysis of composite plates can be extended for FG plates also.

REFERENCES

[1] Devesh Punera, Tarun Kant (2019), "A critical review of stress and vibration analyses of functionally graded shell structures", Composite Structures, 210, pp. 787-809.

[2] Shahistha Aysha, Binol Varghese, Anjali Baby. A review on functionally graded materials, *The International Journal of Engineering and Science*, 2014,3(6),90-101

[3] X. Zhao, Y. Y. Lee, K. M. Liew. Mechanical and Thermal Buckling Analysis of Functionally Graded Plates, *Composite Structures*, 2009,90,161-171

[4] Huu-Tai Thai and Dong-Ho Choi (2012), "An Efficient and Simple Refined Theory for Buckling Analysis of Functionally Graded Plates", Applied Mathematical Modelling, Vol. 36, pp.1008-1022.

[5] Jha D.K., Tarun Kant, and Singh R.K. (2012), "A Critical Review of Recent Research on Functionally Graded Plates", *Composite Structures,* submitted for publication.

[6] Kashtalyan M. (2004), "Three-dimensional elasticity solution for bending of functionally graded rectangular plates", European Journal of Mechanics and Solids, Vol. 23, pp.853-864.

[7] K. Swaminathan and D.M. Sangeetha (2017), "Thermal analysis of FGM plates – A critical review of various modeling techniques and solution methods", Composite Structures, 160, pp. 43-60.

[8] Kyung-Su Na and Ji-Hwan Kim (2004), "Three-Dimensional Thermal Buckling Analysis of Functionally Graded Materials", Composites: Part B Engineering, Vol. 35, pp.429-437.

[9] Majid Badiey and M.A. Kouchakzadeh (2010), "Buckling of a Functionally Graded Plate (FGP) under Shear and In-plane Directional Loading", 27th International Congress of the Aeronautical Sciences.

[10] M.A.R. Loja, C. M. Mota Soares, J.I. Barbosa (2012), "Analysis of Functionally Graded Sandwich Plate Structures with Piezoelectric Skins using B-Spline Finite Strip Method", Composite Structures, 96, pp. 606-615.

[11] U. Parvathy and K. P. Beena (2014), "Linear Static Analysis of Functionally Graded Plate using Spline Finite Strip Method", Composite Structures, 117, 309 – 315.

[12] Ramkumar Kandasamy, Rossana Dimitri, FrancescoTornabene (2016), "Numerical study on the free vibration and thermal buckling behaviour of moderately thick functionally graded structures in thermal environments", Composite Structures, 157, pp. 207-221.

ISBN: 978-93-90214-19-8

[13] A.M. Zenkour, M. Sobhy (2010), "Thermal buckling of various types of FGM sandwich plates", Composite Structures, 93, pp. 93-102.
[14] Samsam Shariat B.A. and Eslami M.R. (2007), "Buckling of thick Functionally Graded Plates under Mechanical and Thermal loads", Composite Structures, Vol. 78, pp.433-439.
[15] Samsam Shariat B.A., Javaheri R. and Eslami M.R. (2005), "Buckling of Imperfect Functionally Graded Plates under In-plane Compressive Loading", Thin Walled Structures, Vol.43, pp.1020-1036.
[16] Serge Abrate (2008), "Functionally graded plates behave like homogenous plates", Composites Part B: Engineering, Vol. 39, No. 1, pp. 151-158.Ganapathi M, Prakash T. (2006), "Thermal buckling of simply supported functionally graded skew plates", Composite Structures,74(2), pp. 247–250.
[17] Lee YY, Zhao X, Reddy JN. (2010), "Postbuckling analysis of functionally graded plates subject to compressive and thermal loads" Computational Methods Appl Mech Engg., 199, pp. 1645–53.
[18] Ghannadpour S.A.M, Ovesy H.R. and Nassirnia M. (2012), "Buckling Analysis of Functionally Graded Plates under Thermal Loadings using the Finite Strip Method", Computers and Structures 108-109, pp.93-99.
[19] Bouazza M, Tounsi A, Adda-Bedia EA, Megueni A. (2010), "Thermoelastic stability analysis of functionally graded plates:An analytical approach", Comput Mater Sci, 49(4), pp. 865–870.
[20] Ramu I. and Mohanty S.C. (2010), "Buckling analysis of rectangular functionally graded material plates under uniaxial and biaxial compression load", Procedia Engineering, 86, pp. 748-757
[21] H. R. Ovesy, S. A. M. Ghannadpour, M. Nassirnia (2015), "Post-buckling analysis of rectangular plates comprising Functionally Graded Strips in thermal environments", Computers and Structures, 147, pp. 209-215.
[22] Pham Toan Thang (2016), "Analytical solution for thermal buckling analysis of rectangular plates with functionally graded coatings", Aerospace Science and technology, Vol. 55,pp. 465-473.
[23] Mostapha Raki, Reza Alipour, Amirabbas Kamanbedast (2012), "Thermal buckling of thin rectangular FGM plate",
World Applied Sciences Journal, 16(1), pp. 52-62
[24] Zbigniew Kolakowski, Leszek Czhechowski (2019), "Non-linear stability of in-plane functionally graded plate", Composite Structures, 214, pp. 264-268.
[25] Birman V. (1995), "Stability of functionally graded hybrid composite plates", Compos Eng.;5(7):913–921.
[26] Feldman E, Aboudi J. (1997), "Buckling analysis of functionally graded plates subjected to uniaxial loading", Compos Struct;38(1-4):29–36.
[27] Ma LS, Wang TJ.(2004), "Relationships between axisymmetric bending and buckling solutions of FGM circular plates based on third-order plate theory and classical plate theory", Int J Solids Struct;41(1):85–101.
[28] Zenkour AM. (2005), "A comprehensive analysis of functionally graded sandwich plates: Part 2—Buckling and free vibration", Int J Solids Struct;42(18-19):5224–5242.
[29] Aydogdu M.(2008), "Conditions for functionally graded plates to remain flat under in-plane loads by classical plate theory", Compos Struct;82(1):155–157.
[30] Saidi AR, Rasouli A., Sahraee S. (2009), "Axisymmetric bending and buckling analysis of thick functionally graded circular plates using unconstrained third-order shear deformation plate theory", Compos Struct;89(1):110–119.
[31] Mohammadi M, Saidi A, Jomehzadeh E. (2010), "Levy solution for buckling analysis of functionally graded rectangular plates", Appl Compos Mater;17(2):81–93.
[32] Meiche NE, Tounsi A, Ziane N, Mechab I, Adda.Bedia EA. (2011), "A new hyperbolic shear deformation theory for buckling and vibration of functionally graded sandwich plate", Int J Mech Sci;53(4):237–247.
[33] Thai HT, Choi DH. (2012), "An efficient and simple refined theory for buckling analysis of functionally graded plates", Appl Math Model;36(3):1008–1022.
[34] Latifi M, Farhatnia F, Kadkhodaei M. (2013), "Buckling analysis of rectangular functionally graded plates under various edge conditions using Fourier series expansion", Eur J Mech A/Solids;41:16–27.
[35] Fekrar A, EI Meiche N, Bessaim A, Tounsi A, Adda Bedia EA. (2012), "Buckling analysis of functionally graded hybrid composite plates using a new four variable refined plate theory", Steel & Compos struct;31:91–107.
[36] Najafizadeh MM, Eslami MR. (2002), "Buckling analysis of circular plates of functionally graded materials under uniform radial compression", Int J Mech Sci;44(12):2479–2493.
[37] Yanga J, Shen H. (2003), "Non-linear analysis of functionally graded plates under transverse and in-plane loads", Int J Non Linear Mech;38(4):467–482.
[38] Yang J, Liew K, Kitipornchai S. (2006), "Imperfection sensitivity of the post-buckling behavior of higher-order shear deformable functionally graded plates.", Int J Solids Struct;43(17):5247–5266
[39] Prakash T, Ganapathi M. (2006), "Asymmetric flexural vibration and thermoelastic stability of FGM circular plates using finite element method", Compos Part B Eng; 37(7-8):642–649.
[40] Shariat BAS, Javaheri R, Eslami MR. (2005), "Buckling of imperfect functionally graded plates under in-plane compressive loading", Thin-Walled Struct;43(7):1020–1036.
[41] Najafizadeh MM, Heydari HR. (2008), "An exact solution for buckling of functionally graded circular plates based on higher order shear deformation plate theory under uniform radial compression". Int J Mech Sci;50(3):603 –612.

 ISBN: 978-93-90214-19-8

Damage Detection in Shallow Tunnels Using 3D Numerical Modelling

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ABSTRACT-Underground structures play an essential role in the transportation system. In metro cities, due to limited space for traffic movement, the formation of underground structures can be beneficial for the transportation system. Underground facilities can be used for various purposes such as railway and highway tunnels, water and gas pipeline, sewage pipelines, and different military purposes. So it becomes very important to determine various parameters which play an essential role in the stability behaviour of tunnels. In this present study, an attempt is made to determine the stability behaviour of shallow tunnels under static loading conditions. The study is conducted on numerical software, i.e. ANSYS. It is very difficult to assess the stability behaviour of tunnels in actual field conditions. With the help of numerical tools, it becomes very easy to determine the deformation of tunnels. Tunnels are subjected to various type of loading. The stability of tunnels under static loading conditions is checked. From the results, it can be concluded that there are various factors that affect the stability behaviour of tunnels. It can also be concluded that shallow tunnels are more vulnerable to damage as compared to deep tunnel. As the overburden depth of the tunnel increase, the effect of damage will decrease. The presence of lining material can also reduce the extent of deformation in the tunnel structures.

Keywords: Boundary Conditions, Lining, Meshing, Static Loading, Underground Structures

1. INTRODUCTION

With the growing degree of urbanization in modern societies, underground systems are becoming increasingly common in urban areas. Subway tunnels and other underground infrastructure are excavated underneath existing buildings, or buildings are constructed on top of underground structures. As a result, current overburden loads and potential surface loadings must be factored into tunnel design. Tunnels, on the other hand, must be excavated under the groundwater level in realistic cases, such as cross-river tunnels. The effect of the water table level on the tunnel lining behaviour must also be investigated. In congested cities, tunnelling is an efficient way to meet the increasingly rising traffic demand. The number of subways has risen rapidly in recent decades as a result of the urgent need to boost traffic and build environmentally sustainable infrastructure in congested urban areas. Subway station tunnels are known for their shallow depths, long lengths, and large sections.

Metro systems have been built in major cities all over the world in recent years. Once the tunnel is constructed, they experienced major settlement problems. This may be due to the surrounding disturbance nearby the tunnel vicinity. It is also seen that, the construction of a new tunnel effect the stability behavior of already existing tunnel. If the two tunnels are closely spaced then, they will face settlement problems in future. Multiple tunnels are common in engineering practices since constructing multiple smaller tunnels is usually less expensive than building a single larger tunnel. Many studies shows that the settlement experienced in vertically aligned tunnels is more as compared to the settlement experienced in horizontally aligned tunnels. The construction method adopted for the excavation of the tunnel also effects the settlement of the tunnel. In these conditions, correctly measuring the stability of several tunnels subjected to surcharge loading is a critical problem that must be addressed with special care in tunnelling practice. Several researchers have proposed several computational simulation solutions for calculating the deformations in tunnels. Chou et al. (2002) studied the deformation behaviour of tunnel at shallow depth in the clayey medium. Stress and displacement induced in tunnel lining were determined and from the results, it is concluded that the vertical displacement value obtained in the tunnel section is very large as compared to the horizontal deformation. Sahoo et al. (2012) study the behaviour of long tunnel under seismic loading and found that the deformation behaviour depends upon the variation in the stability number and nodal velocity pattern. Wang et al. (2012) studied the settlement behaviour of tunnel in clay at shallow depth using FEM techniques and found that settlement depends upon the creep behaviour of clay. Zhang et al.(2015) studied the tunnel behaviour in a cohesive soil and concluded that the tunnel stability behaviour depends upon the cover depth and cohesion of soil. Li et al. (2016) studied the deformation behaviour of the tunnel at the intersection and the results show that the extent of deformation is more in the case of the tunnel close to the intersection. Paternesi et al.(2017) studied the settlement behaviour of reinforced and unreinforced tunnel using computational techniques and found that the effect of deformation is more in the case of an unreinforced section. Li et al.(2018) studied the dynamic response of the tunnel under blast loading and found that in the case of blast loading the maximum deformation is experienced at the roof and floor of the tunnel. Shahin et al. (2019) stated that three-dimensional finite element study of the tunnel behaviour is very essential for determining the exact tunnel design parameters. Zhang et al. (2019) concluded that spacing between the tunnels affects the settlement behaviour. Chen et al. (2020) conducted a numerical study to determine the failure behaviour of tunnel with the help of finite element analysis and found that the formation of plastic hinges that occurred in joints is the main reason behind the failure of the segmental ring in the tunnel shield. Rashiddel et al. (2020) studied the effect of explosive loading on the segmental tunnel lining and concluded that in the case of explosive condition the curved jointed segmental lining is very efficient. Shiau et al. (2020) explained the importance of various factors such as cohesion, unit weight, surcharge loading on the displacement In tunnels. Yang et al. (2020) explained the importance of soil parameter in the settlement of surface in the metro tunnel. Heidarzadeh et al. (2021) explained the best suitable criteria for the determination of damage in tunnels using numerical techniques and it is concluded that for the tunnels excavated in hard rock, the non-linear elastoplastic model is the best option. Qian et al. (2021) studied the effect of blasting on tunnel behaviour and found that by providing better reinforcement in the tunnel section, the effect of blast loading can be minimized.

2. Selection of Model Material

Plaster of Paris material is chosen for this study as a model material. Various properties of the model material are determined through laboratory tests to classify the material. The properties of the model material are discussed in Table 1. The water is added to the model material to make a uniform paste then the prepared paste of the model material is used to make the cylindrical samples of diameter 38mm and length 76mm to determine the basic engineering properties.

Table 1: Properties of the model material

Property	**Value**
Specific Gravity	2.7
UCS (MPa)	9.5
Tensile Strength (MPa)	.45
Modulus of Elasticity (MPa)	2600
Poisson Ratio	.22
Initial Setting Time (min)	30

3. Model Geometry

The geometrical dimension of the tunnel model is decided according to the boundary conditions. The dimension of the model is kept 30x25x23cm (LxWxH). The width of the tunnel model is decided according to (r=4a, where “r” is the radial distance and “a” is the radius of the tunnel. The diameter of the tunnel is decided as 5cm in this study. In the present study, the cover depth of the tunnel is varied as 3cm and 5cm.PVC pipe is used as a liner material in the case of lined tunnel samples. The modulus of elasticity of the PVC pipe is 5100MPa.A steel patch is also provided at the top of the tunnel load through which the load is transferred to the centre of the tunnel sample. The diameter of the steel patch is 5cm and the height of the steel patch is around 7cm.

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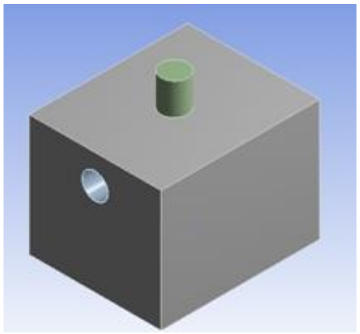

Fig 1: Single Tunnel Model

4. Meshing and Boundary Conditions

Meshing to the tunnel is provided according to the mesh convergence study. Mesh size of 12mm is provided to the tunnel rock mass of dimension 30x25x23cm. On the steel section which is placed at the top surface of the tunnel sample, a mesh size of 10mm is provided whereas along the tunnel lining i.e. PVC pipe the mesh size of 10mm is given. When the tunnel model is generated after providing meshing to it, it contains 1,45,623 elements and 55,264 nodes in total. As far as boundary conditions are concerns, the bottom part of the tunnel model is kept fixed so that during the application of the load on the tunnel sample, the sample remains at a constant place. All the other sides are left free toward the displacement. The load is applied from the top of the sample, through a steel patch and then it is transferred to the tunnel sample. The meshed tunnel sample along with the steel patch and the liner material is shown in Fig 2.

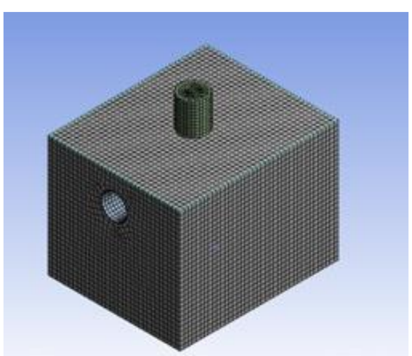

Fig 2: Meshing Element

5. Numerical Analysis of Single Tunnel

The tunnel models after giving the basic engineering properties and meshing size are subjected to static loading conditions. The load is applied from the top face on the tunnel sample. After the application of the load, the tunnel deformation is allowed in the vertical direction. The deformation in the tunnel lining is taken at three different locations i.e. L/2, L/3 and 7L/12. The deformation computed in the tunnel lining is discussed in the result and discussion section. The deformed tunnel sample after the application of load is shown in Fig 3.

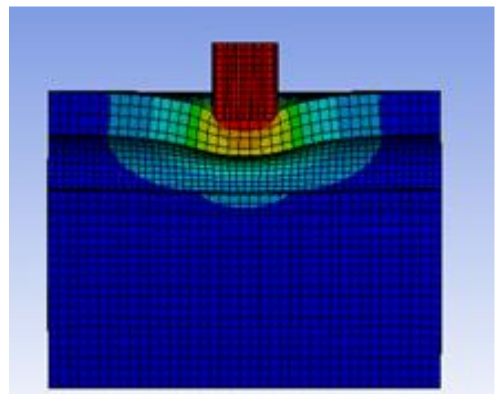

Fig 3: Deformation in Tunnel sample

6. Result and Discussion

When the tunnel sample is subjected to static loading conditions, deformation occurs along the length of the tunnel. Both lined and unlined samples of Plaster of Paris material are subjected to static loading condition. The cover depth of the sample is varied as 3cm and 5cm from the top surface of the tunnel. From the results, it can be observed that deformation in the case of unlined tunnel sample is more as compare to lined tunnel samples. Whereas the cover depth also plays an important role in the deformation behaviour of the tunnel. Table 2 shows the deformation obtained in unlined and lined tunnel sample when subjected to the static loading conditions. The deformation profile obtained in the case of the unlined and lined tunnel sample is shown in Fig 4. In the case of unlined samples, the maximum deformation is experienced at L/2 i.e 0.22 mm in the case of 3cm cover depth. Whereas in the case of a 5cm cover depth unlined sample, the

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maximum deformation measured at L/2 distance is 0.18 mm. In the case of the lined sample, the maximum deformation is experienced at L/2 is 0.09mm in the case of 3cm cover depth. In the case of a 5cm cover depth sample, the maximum deformation measured at L/2 distance is 0.08 mm.

Table 2: Deformation obtained in the lined and unlined tunnel under static loading conditions.

Tunnel Section	Cover Depth	Deformation in mm		
		L/3	L/2	7L/12
Unlined Tunnel	3cm	0.05	0.22	.13
	5cm	0.02	0.18	.08
Lined Tunnel	3cm	0.02	0.09	.06
	5cm	0.01	0.08	.03

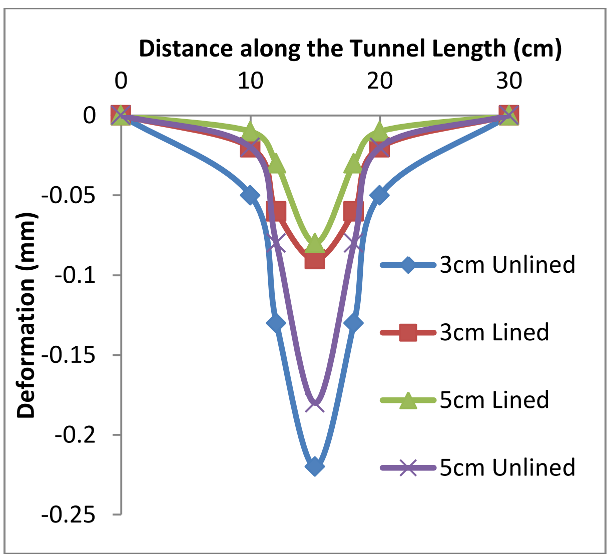

Fig 4: Deformation graph of lined and unlined tunnel samples.

Conclusions

In the present study, an attempt is made to determine the damage experienced in the shallow tunnel under static loading conditions. For this FEM technique is used with the help of ANSYS software. The following conclusions are drawn from the present study.

i. The extent of damage in the case of a shallow tunnel depends upon two main factors i.e. the cover depth of the tunnel and the presence of liner material.
ii. In the case of the unlined tunnel sample, the extent of damage is comparatively more as compared to the damage noticed in the lined sample. This is due to the presence of liner material in the lined sample which offers resistance against the deformation.
iii. From the results, it can be concluded that the maximum value of the deformation is noticed at the centre of the tunnel length i.e. L/2.
iv. The deformation value obtained at the end faces of the tunnel is zero in all the cases. This means that the effect of deformation decreases as the distance from the centre point towards the end face of the tunnel increases.

Acknowledgement

The authors are thankful to the Department of Civil engineering, Delhi Technological University for their support. Special thanks to the laboratory staff of the rock mechanics lab and CADD lab for their help during the study.

References

1. Chen.R.P.,Chen.S.,Wu.H.,Liu.Y.and Meng.F.,"Investigation on deformation behaviour and failure mechanism of a segmental ring in shield tunnels based on elaborate numerical simulation", Engineering Failure Analysis,117,104960,1-15,2020.

2. Chou.W. and Bobet.A.,"Predictions of ground deformations in shallow tunnels in clay", Tunnelling and Underground Space Technology,17,3-19,2002.

3. Heidarzadeh.S.,Saeidi.A.andRouleau.A.,"The damage-failure criteria for numerical stability analysis of underground excavations: A review",Tunnelling and Underground Space Technology,107,103633,1-17,2021.

4. Li.Y.,Jin.X.,Lv.Z.,Dong.J. and Guo.J.,"Deformation and mechanical characteristics of tunnel lining in tunnel intersection between subway station tunnel and construction tunnel",Tunnelling and Underground Space Technology,56,22–33.2016.

5. Li.X.,Li.C.,Cao.W. and Tao.M.,"Dynamic stress concentration and energy evolution of deep-buried tunnels under blasting loads", International Journal of Rock Mechanics and Mining Sciences,104,131–146,2018.

6. Paternesi.A.,Schweiger.H.F.and Scarpelli.G.,"Numerical analyses of stability and deformation behavior of reinforced and unreinforced tunnel faces", Computers and Geotechnics,88,256–266,2017.

7. Qian.H.,Zong.Z.,Wu.C.,Li.J.andGan.L.,"Numerical study on the behavior of utility tunnel subjected to ground surface explosion",Thin–Walled Structures,161,107422,1-18,2021.

8. Rashiddel.A., Kharghani.M., Dias.D. and Hajihassani.M.," Numerical study of the segmental tunnel lining behavior under a surface explosion– Impact of the longitudinal joints shape", Computers and Geotechnics,128,103822,1-14,2020.

9. Sahoo.J.P. and Kumar.J.," Seismic stability of a long unsupported circular tunnel", Computers and Geotechnics,44,109–115,2012.

10. Shahin.H.M.,Nakai.T.andOkuno.T. (2019),"Numerical study on 3D effect and practical design in shield tunneling", Underground Space, 4, 201–209, 2019.

11. Shiau.J.and Al-Asadi.F., "Two-dimensional tunnel heading stability factors Fc, Fs and Fγ", Tunnelling and Underground Space Technology,97,103293,1-10,2020.

12. Wang.Z.,Wong.R.C.K.,Li.S. and Qiao.L.," Finite element analysis of long-term surface settlement above a shallow tunnel in soft ground",Tunnelling and Underground Space Technology,30,85–92,2012.

13. Yang.J.,Yin.Z.,Liu.X.F. and Gao.F.P.,"Numerical analysis for the role of soil properties to the load transfer in clay foundation due to the traffic load of the metro tunnel", Transportation Geotechnics, 23,100336,1-13,2020.

14. Zhang.C.,Han.K.andZhang.D.,"Face stability analysis of shallow circular tunnels in cohesive–frictional soils",Tunnelling and Underground Space Technology ,50,345–357,2015.

15. Zhang.R.,Xiao.Y.,Zhao.M.andZhao.H.(2019),"Stability of dual circular tunnels in a rock mass subjected to surcharge Loading", Computers and Geotechnics,108,257–268,2019

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ISBN: 978-93-90214-19-8

Design and Comparative Analysis of Step Back and Set Back Residential Framed Structure

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***Abstract*— The layout of Step back and set back systems are to a first-rate quantity emphasized in terrain regions wherein the ground surfaces are properly undulated regions. There is a scarcity of simple ground surfaces in hilly areas which in the long run leads challenging project for production of the infrastructure like RCC buildings, Rehabilitation centers, Primary fitness care facilities, places of work on the present undulated floor. As the performance of the systems in earthquake time without delay proportional to Mass distribution, stiffness in each the planes of the structure which vary in framed structures in hill slopes with regularity and asymmetry due to setback Step again and step returned buildings. The objective of the paper is to know the Comparative evaluation of Seismic forces, Shear, time period and fundamental criteria of better performance in the configuration of Step back Set again building and the Step again building during the earthquake floor movement.**

Index Terms—*Step back constructions, set back constructions, Seismicity, time period, stiffness, displacement.*

I. INTRODUCTION

This country having the arc of mountains possessing Himalayas defines the northern Indian subcontinent. As per Indian Census, these are resultant of continues tectonic collision of Indian and European plates which have densities of houses of 62159.2 per Sq Km [1]. There is a shortage of plain ground surfaces in hilly regions which ultimately leads challenging task for construction of the infrastructure like RCC structures, Rehabilitation centers, Primary health care centers, offices on the existing undulated ground. As the performance of the structures in earth quake time directly proportional to Mass distribution and stiffness in both the planes of the structure which are vary in hilly framed structures with regularity and asymmetry because of Step back set back and step back constructions. In Seismically Prone areas, the presence of such construction makes them exposed to greater shears and torsion as compared to conventional construction [2]. Framed structures on hilly places have different dynamic characteristics on comparing with constructions on level ground surfaces like topography. The asymmetrical variation of stiffness and mass in vertical in conjunction with horizontal directions, results in middle of mass and center of stiffness of a tale not coinciding with every other and not being on a vertical line for different floors. When subjected to lateral masses, those systems are usually subjected to tremendous torsional reaction. Depending upon the web site situations, the systems on hill slopes are characterized by way of variable in column heights with in a story, which leads to drastic version in stiffness of columns of the same story. The columns that are quick on uphill aspect interest a lot complex lateral forces and are at risk of harm. Henceforth, there is a requirement to study on the seismic wellbeing and design of these structures on slopes [3].

II. MODES OF STRUCTURES ON HILLS

A. Methods of analysis

The procedures of analysis are Equivalent static analysis, Response spectrum analysis, Time history analysis, Pushoveranalysis [4].

B. Objective

3D analysis is conducted for three modes of constructions (setback building, step back building, step back set back building) for G+4 & G+5 storey resting on sloping ground varying from 0^0 to 35^0 for seismic load. Dynamic response properties like base shear, top floor displacement, time period induced in the structure according to the appropriateness of a building formation on sloping ground were studied.

C. ETABS

“ETABS stands for Extended Three-Dimensional Analysis of Building Systems” [5]. This package provides a quantum leap advancing in the way models are created, modified, analyzed and designed. The modelling is completely combined with steel and concrete structures with greater accuracy. The analytical competences of ETABS are just as impressive and represents the latest research in numerical procedures and algorithms.

III. PROBLEM STATEMENT

In the existing study, three modes of building are considered, such that two are resting on sloped surface and third one is on levelled surface. One mode is step back constructions and other is step back-setback constructions and third is the setback building. In sloped ground, the height of the column is dissimilar at the bottom storey. It is asymmetric in plane and elevation. The structural assessment subjected to seismic load has been carried out without any importance on cost of construction.*Modelling*

Modeling of the structure is different while comparing step back and step back set back modes. Structure is modeled using standard package ETABS. Beams and columns are modeled as nodded elements with six DOF at each node.

Table I Geometric Properties

No. of stories	G+4, G+5
Bays along X	4
Bays along Y	4
Length of each bay	3.5m
Bottom storey height	4.7m
Height of the storey	3m

Table II Properties of Materials

Grade of concrete	M30
Grade of steel	HYSD 550
Beam	450 × 600 mm
Column	450 × 750 mm
Slab thickness	150mm
For bottom storey	
Grade of concrete	M60
Grade of steel	HYSD 550
Column size	1000 x 700 mm

Table III Seismic Properties

Seismic zone	IV
Type of soil	Rock/hard
Type of frame	Ordinary moment resisting frame (OMRF)
Damping ratio	5%
Building use	Residential

A. Modal Combination Instructions

The common approaches for finding the maximum response interest for a MDOF system are Absolute sum (ABSSUM) method, Square root of sum of squares (SRSS) method, and Complete quadratic combination (CQC) method [6].

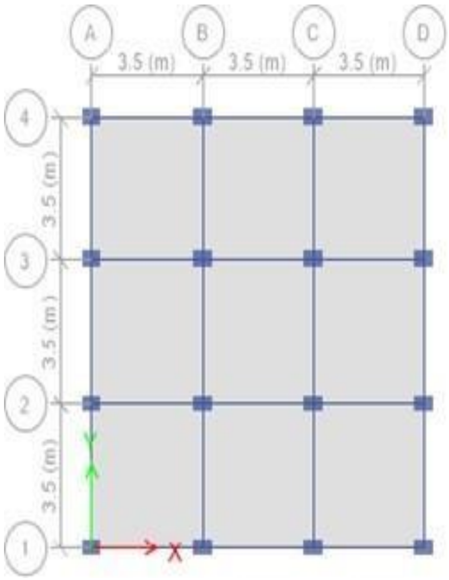

Figure I Plan of G+4 Structure

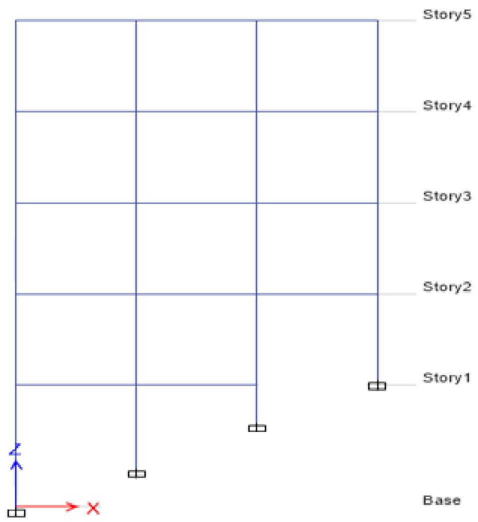

Figure II 25-degree Step back structure

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1) Absolute Sum (ABSSUM) Method:

In ABSSUM method, “the peak responses are added algebraically, assuming that all nodal peaks occur at same time” [7]. The ABSSUM method provides a much conservative estimate of resulting response quantity and thus provides an upper bound to peak value of total response.

2) Square Root of Sum of Squares (SRSS) Method:

The SRSS is “method of combining maximum modal responses is fundamentally sound where the modal frequencies are well separated” [7]. Nevertheless, this technique yields poor results wherever frequencies of major contributing modes are very close together.

3) Complete Quadratic Combination (CQC) Method:

The response of a structure can be well-defined as a combination of many special modes that in a vibrating cord correspond to the "harmonics" complete quadratic combination (CQC) [8] – a method that is an improvement on SRSS for closely spaced modes.

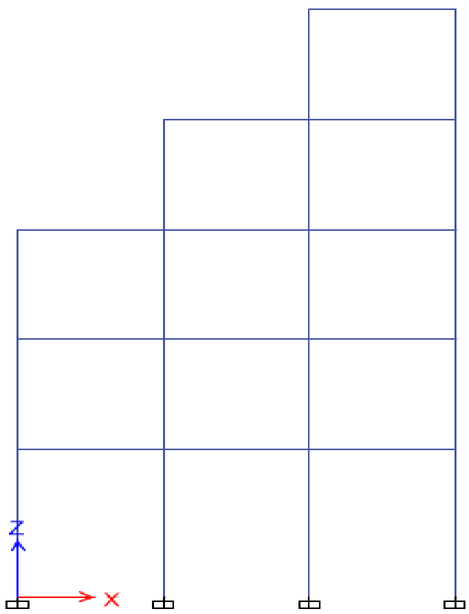

Figure III 0-degree setback structure

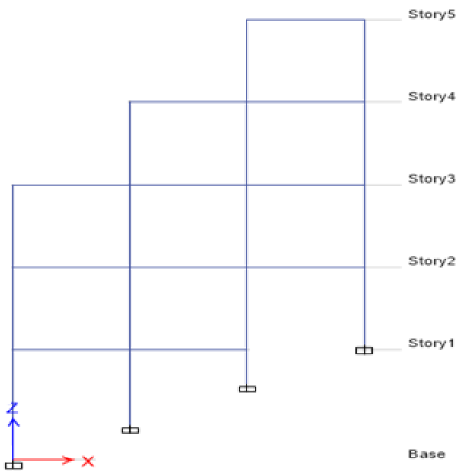

Figure IV 25-degree Step back Set back Structure

In the similar fashion, we have done modelling for 5- storied structure for different degrees of setback, step back & step back setback structure. By the application of loads we can be able to find out the deformations and shapes of deformations.

IV. RESULTS

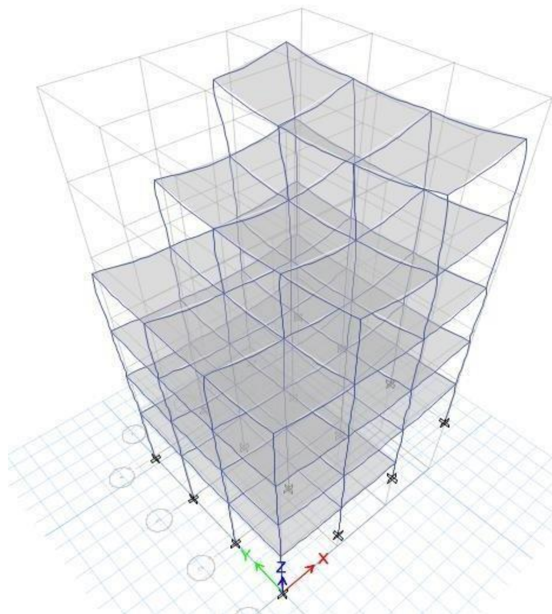

Figure V Deformation of Step Back Set Back Configuration

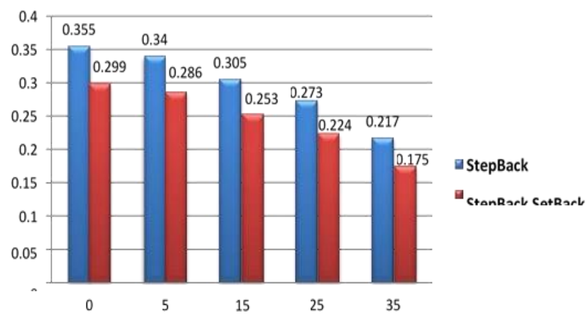

Figure VI Deformation of 25-degree Step back Set back structure

Table IV Time period for G+4 Structure configuration

Slope in degrees	Time period for step back building in sec	Time period for stepback set back in sec
0°	0.355	0.299
5°	0.34	0.286
15°	0.305	0.253

ISBN: 978-93-90214-19-8

25°	0.273	0.224
35°	0.217	0.175

Figure VII Time period for step back & set back configuration

V. Observations

The columns at extreme right draws most shear. The time period decreases with the growth in slope. Stiffness will increase with the increase of slope. The top storey displacement in step again set returned building configuration is much less than step back building. The configuration of Step back Set back constructing ensuing into better overall performance than the Step again constructing at some stage in the earthquake floor movement, provided the fast columns are sorted in layout and detailing. As the no. Of storey increases the building frame prove to be more prone.

Table V ***Time period of step back set back building configurationfor (G+4) and (G+5)***

Slope in degrees	Time period for (G+4) step back set back building in sec	Time period for (G+5) step back set back building in sec
0°	0.299	0.34
5°	0.286	0.336
15°	0.253	0.322
25°	0.224	0.291
35°	0.175	0.238

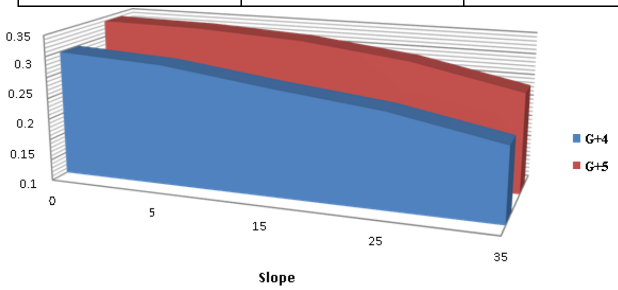

Figure VIII Time period set back building configuration for (G+4)and (G+5)

Table VI ***Base shear of step back building configuration for(G+4) and (G+5)***

Slope in degrees	Base shear for (G+4) step back building in KN	Base shear for (G+5) step back building in KN
0°	680.55	793.59
5°	675.675	773.08
15°	650.637	756.13
25°	610.004	735.48
35°	564.387	689.88

VI. Conclusions

The columns at extreme right attracts maximum shear. The time period decreases with the increase in slope. Stiffness increases with the increase of slope. The top storey displacement in step back set back building configuration is less than step back building. The mode of Step back Set back construction results into better performance than the Step back building during the earthquake, provided the short columns are taken care of in design and detailing. As the no. of storey increases the building frame prove to be more vulnerable.

VII. References

[1] Y. R. Likhitharadhya and P. G. Student, "Seismic Analysis of Multi-Storey Building Resting On Flat Ground and Sloping Ground," *Int. J. Innov. Res. Sci. Eng. Technol. (An ISO*, vol. 3297, 2007.

[2] P. G. Mistry and H. J. Shah, "Seismic Analysis of Building on Sloping Ground Considering Bi- Directional Earthquake," *Int. J. Sci. Dev. Res.*, vol. 1, no. 4, 1604, Accessed: Mar. 07, 2021. [Online]. Available: www.ijsdr.org.

[3] Y. Singh, P. Gade, D. H. Lang, and E. Erduran,"Seismic Behavior of Buildings Located on Slopes-An Analytical Study and Some Observations FromSikkim Earthquake of," 2011. Accessed: Mar. 07,2021.[Online]. Available: https://www.iitk.ac.in/nicee/wcee/article/WCEE201 2_4201.pdf.

[4] G. P.-S. and M. Optimization and undefined 2011, "Technical overview of the equivalent static loads method for non-linear static response structural optimization," *Springer*, Accessed: Mar. 07, 2021. [Online]. Available: https://link.springer.com/content/pdf/10.1007/s00158-010-0530-x.pdf.

[5] "Structural Software for Building Analysis and Design | ETABS," 2015. .

[6] S. He, K. Bremme, and M. Blombä Ck, "A Laboratory Method for Determination of Overall Haemostatic Potential in Plasma. I. Method Design and Preliminary Results-sums also changed in positive relation to the haemostatic function inves," 1999. Accessed: Mar. 07, 2021. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0049384899000924.

[7] E. L. Wilson, A. Der Kiureghian, and E. P. Bayo, "A replacement for the srss method in seismic analysis," *Earthq. Eng. Struct. Dyn.*, vol. 9, no. 2, pp. 187–192,1981.

[8] "• Rayyan-Ul-Hasan Siddiqui and , H. S. Vidyadhara... - Google Scholar." .

Comparative Analysis of Circular and Spin Fin Pile for Axial Loading

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Abstract - Conventional circular piles are more commonly used for onshore as well as offshore structures due to their ease of installation. However, in some crictical cases to develop significant vertical capacity during driving the use these circular piles are not reliable. Spin fin pile foundation is an innovative modification over a conventional circular pile foundation. Spin fin piles are traditional pipe piles fitted with steel plates; fins are attached at a slight angle over the upper or bottom portion of circular piles. This paper presents a numerical solution for axially loaded circular pile and triangular shape spin fin pile group in linear-elastic soil profiles. In this study, a MIDAS GTS-NX software are used to developed model with an elastic plastic soil model, an elastic pile material and interface elements. The behaviour of circular pile and triangular shape spin fin pile with loose sand and medium dense sand for different slenderness ratio are examined. The load distribution within the pile and the settlement of the pile are presented. Analysis shows that, the vertical resistance increases in triangular shape spin fin pile as compare to circular pile.

Index Terms - circular pile, MIDAS GTS-NX, settlement, Spin fin pile, vertical resistance

I. INTRODUCTION

Piles are adopted as foundation where large loads or weak soil comes in frame. There are various structures like bridge abutment, transmission towers, chimneys, ocean engineering structures, marine dolphins etc. are subjected to large vertical loading condition. Vertical resistance will be smaller for these types of loads in case of conventional circular pile, hence needs improvement. Pile foundations are generally long and slender members.

Spin Fin pile is a modification over a conventional pile foundation, introduced by PND Engineers in 1983. Spin fin piles are described as a traditional pipe piles fitted with, steel plates called as fins. These fins are attached at a slight angle over the upper or bottom portion of circular piles. The geometry of the spin fin pile is such that when it is viewed from bottom to top, the top of one fin meets the bottom of the adjacent fin, thus providing 360 degree coverage. These fins are attached along the periphery of circular pile L. R. Chernauskas et al. (2009). The name for the spin fin pile is derived from the fact that the pile actually rotates while being driven due to the angled fins, much like a screw. While driving in it forms bond with soil surrounding the fins making it tightly fit in soil and hence improves the transmission of load more effectively than simple circular pile.

II. REVIEW OF LITERATURE

Ahmed M. A. Nasr et al. (2013) carried out experimental investigation on laterally loaded finned piles in sand. In which the improvement in lateral capacity of a pile with fins mounted close to the pile head was evaluated. The tests and analysis were carried out by varying the density, length, width, shape of the fins (Triangular and rectangular) and type of pile. A comparison between the model results and the prototype-scale results were studied. It was concluded that piles with fins provided considerably higher ultimate lateral loads and lateral resistance compared with a regular reference pile.

Mohamed A. Sakr et al. (2019) carried out investigation on single pile with triangular shaped wings in sand for uplift loading condition. A numerical study utilizing finite component examination PLAXIS-3D was run on piles without wings and with wings. Studies were done by changing the wing-width proportion, number of wings. The effects of sand relative densities were moreover considered. Results indicated that the adopted wings at the pile end have an impressive impact in increasing the uplift load carrying capacity with lesser deformation.

S. W. Thakare et al. (2019) studied performance of spin fin pile under different loading modes. In the experimental investigation, three different positions of fins in the spin fin pile were considered viz., fins at botto m, middle and top of the pile. The results show that spin fin pile with fins at bottom provides much higher vertical and uplift capacity compared to that of conventional circular pile. Spin fin pile with fins at top provides higher lateral load capacity compared to conventional circular pile.

N.G. Tale et al. (2019) carried out numerical analysis of spin fin pile under different loading using MIDAS GTS 3D software. Studies were done by changing the relative density of soil, loading conditions and positions of fin. Analysis shows that spin fin pile with fins at bottom provides higher vertical capacity compared to that of conventional circular pile.

P. Bariker et. al. (2020) conducted an experimental study on lateral resistance of triangular fin piles in sand. The study is extended to evaluate the behaviour of varying length of pile, fin position, number of fin wings, dimensions of fins and type of pile that are embedded in sand of varying relative density. It was concluded that fin piles provide considerably more lateral resistance compared to regular pile and also fins placed near the pile head provides more resistance than that of pile bottom.

NUMERICAL MODELLING

A three-dimensional (3D) finite element model was established in order to analyse the behaviour of circular pile and triangular shape spin fin pile. The computations were carried out using the finite element program system MIDAS GTS-NX. Which is a finite element based software package, most commonly used for numerical analysis for solving variety of Geotechnical Engineering problems. The advantage of developing such a finite element model is that it can be used to examine various configurations that have not been modeled experimentally in the study. The sand was assumed to be a linear elastic perfectly plastic material. The Mohr–Coulomb (MC) material model was used to simulate the nonlinear sand behavior because of its simplicity, reasonable number of model parameters, and reasonable accuracy in modelling. An elastoplastic analysis under drained conditions was used to model piles with the yield of the sand, defined by the Mohr–Coulomb model. The elastic– plastic Mohr–Coulomb model involves five basic input parameters: elasticity modulus (E), Poisson's ratio (μ), internal friction angle (φ), cohesion (c), and dilatancy (Ψ). The angle of internal friction and elasticity modulus of the sand were calculated based on the direct shear test results for the loose and medium dense sands. Soil properties used in finite element analysis are given in Table 1. Hollow portion of circular and spin finned pile were filled with sand having same properties as shown in table 1 for loose sand and medium dense sand respectively. Fin and pile properties used in finite element analysis are given in Table 2.

Table 1: Properties assigned to soil used in finite element analysis

Parameter	Symbol	Loose Sand	Medium Dense Sand
Relative Density of soil	Dr (%)	40	55
Unit Weight of soil	ϒ(kN/m^3)	16.33	16.5
Young's modulus	E (MPa)	20000	27000
Poission's ratio	μ	0.3	0.3
Angle of internal friction	φ (^{0})	34	37.88
Cohesion	c (kN/m^2)	1	2

Table 2: Properties of pile used in finite element analysis

Parameter	Symbol	Value
Pile outer diameter	D (m)	1.2
Pile wall thickness	T_p (m)	0.075
Fin wall thickness	T_f (m)	0.075
Length of pile	L_p (m)	18, 24, 30
Length of fin to length of pile	L_f / L_p	0.5
Width of fin	B_f (m)	0.6
Slenderness ratio	L/D	15, 20, 25
Spacing of Pile	S (m)	3*D
Size of Pile cap	(m)	S+2D+0.3
Depth of Pile cap	(m)	0.6

Type of material		Mild steel
Poisson's ratio	μ	0.3
Modulus of elasticity	E (GPa)	200

It was assumed that the pile was installed in a normally consolidated sand with Ko= 0.42. It should be noted that interface elements were applied between the sand filling and the pile in order to model the sand filling – pile interaction. Along the pile the strength reduction factor of the interface is set to 0.65 which is typical of sand -steel interfaces. This factor relates the interface properties to the strength properties of a soil layer as follows:

$$\tan\phi^{i} = R_{int} \tan \phi'$$

$$C_i = R_{int}\, C'$$

$$\Psi_i = 0 \text{ if } R_{int} < 1 \text{ otherwise } \Psi_i = \Psi$$

Where ϕ^i, C_i and Ψ are the friction angle, cohesion and dilatancy angle of the interface, respectively. The triangular shape fined pile and circular pile, shown in Fig. 1. were assumed to be linear elastic mild steel material which has typical properties of Young's modulus, E = 200 GPa, Poisson's ratio, μ = 0.3, and unit weight, Υ = 78 kN/m^3.

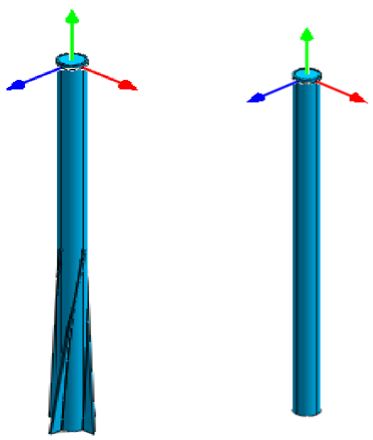


Fig. 1: a) Three dimensional view of geometric modelling of triangular shape spin fin pile and b) conventional circular pile

The 3D Geometry of the Embedded Pile and the Soil Mesh

The three-dimensional finite element program, MIDAS GTS-NX was chosen to model the finned pile and the sand. The boundary is a cube with sides of 22.5 times the diameter of the pile and a depth 2.5 times the length of pile (J. R.Peng, 2010). The vertical load responses and load capacities of triangular shape fin piles embedded in sand were investigated in comparison to conventional circular piles. For comparative analysis, the cross section area of triangular shape fin pile and conventional circular pile was same throughout.

The investigations were carried out by varying the slenderness ratio of pile (L/D), relative density of soil for single and group of pile. The analysis was done on single as well as group of three, four, five and six pile with varying slenderness ratio. The geometry of a three-dimensional model of group of four spin finned pile embedded in soil is shown in Fig. 2. The bottom boundary was fixed against movements in all directions, whereas the 'ground surface' was free to move in all directions. The vertical boundaries were fixed against movements in the direction normal to them.

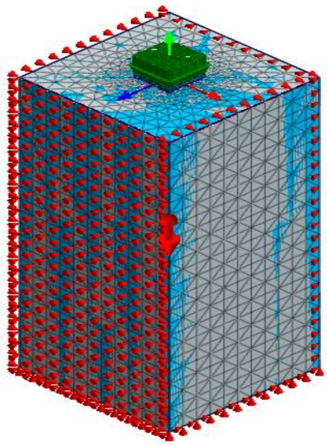
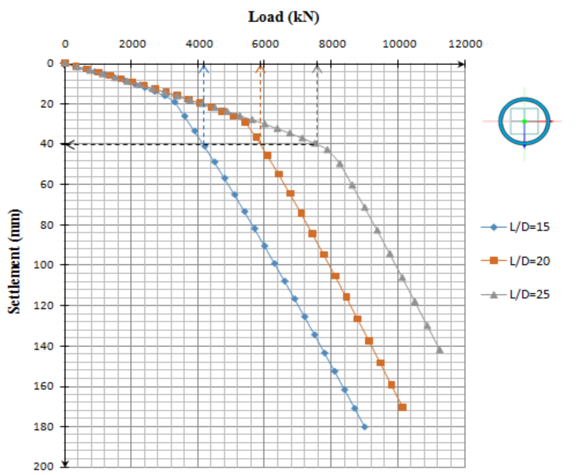


Fig.2: Three dimensional view of group of four spin finned pile embedded in soil

III. INTERPRETATION AND DISCUSSION OF RESULTS

The analyses were conducted on conventional circular pile and triangular shape spin fin pile for loose and medium dense condition. The load - settlement curves for these pile subjected to vertical loading in loose and medium dense sand for L/D ratio = 15, 20, 25 are plotted. The ultimate vertical load of pile was obtained as per criteria laid down by IS: 2911-2013 (Part- IV). The effects of selected parameter on ultimate load capacities of piles were determined and results for triangular shape spin fin piles were compared with those of conventional circular pile having same cross section area. Vertical load and settlement (*P*–*Y*) curves from the results of the numerical analyses for conventional circular pile is shown in Fig. 3. The same patterns are followed for group of conventional circular pile. Due to space limitation only some of curves are shown. Vertical load and settlement (*P–Y*) curves for spin fin pile are shown in Fig. 4 - 8.



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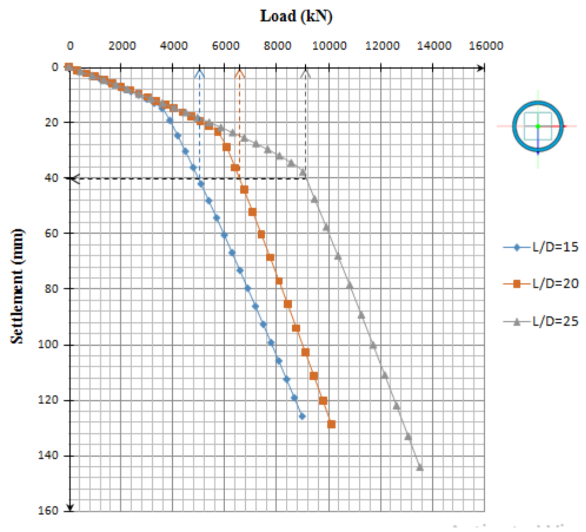
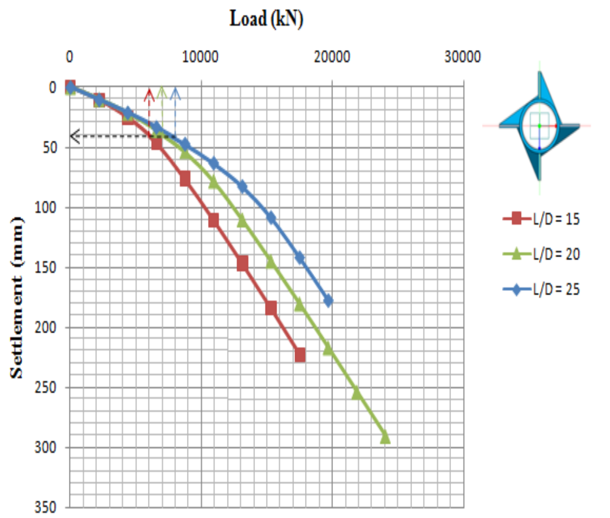


(b)

Fig. 3: Load vs. Settlement Curves for Single Conventional circular Pile for Vertical Loading in (a) Loose Sand (b) Medium Dense Sand



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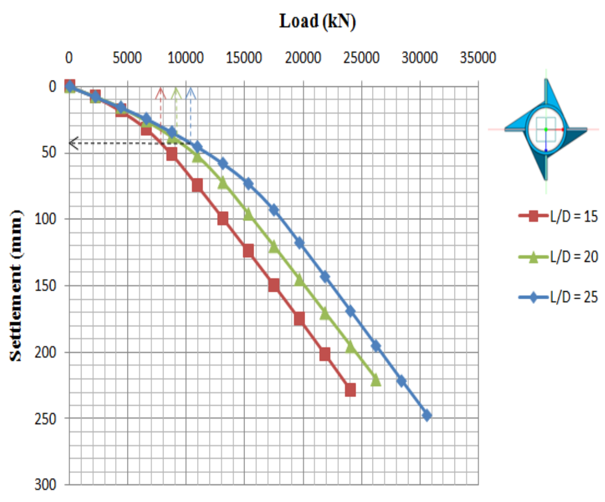
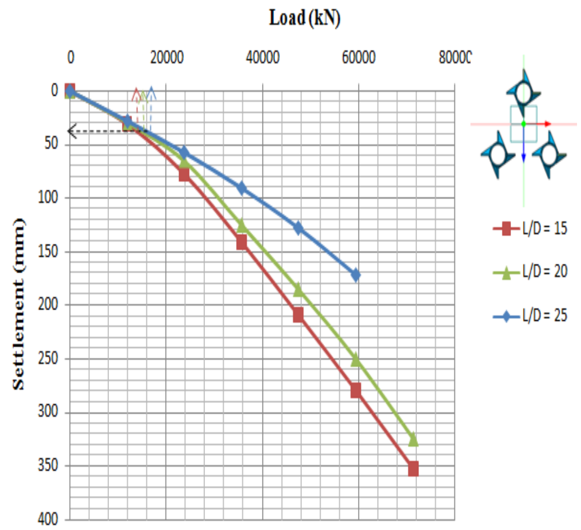


(b)

Fig. 4: Load vs. Settlement Curves for Single Spin Fin Pile for Vertical Loading in (a) Loose Sand (b) Medium Dense Sand

ISBN: 978-93-90214-19-8



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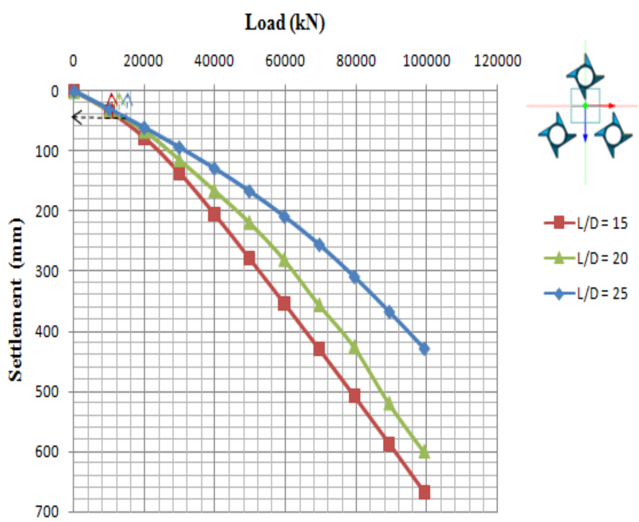
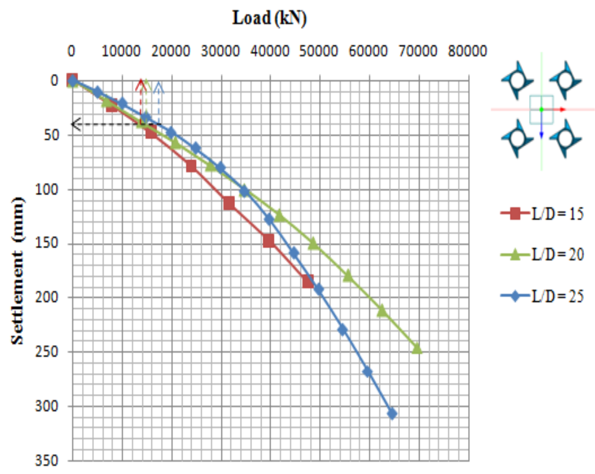


(b)

Fig. 5: Load vs. Settlement Curves for Three Spin Fin Pile for Vertical Loading in (a) Loose Sand (b) Medium Dense Sand



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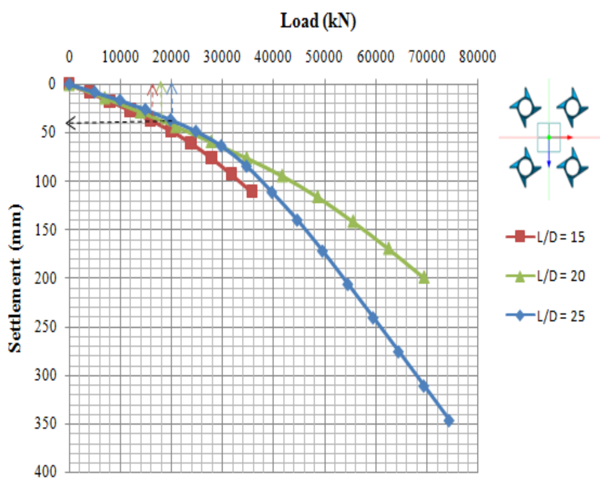
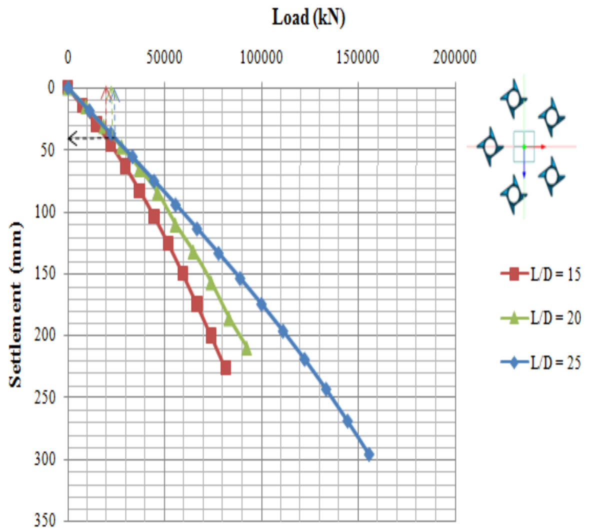


(b)

Fig. 6: Load vs. Settlement Curves for Four Spin Fin Pile for Vertical Loading in (a) Loose Sand (b) Medium Dense Sand



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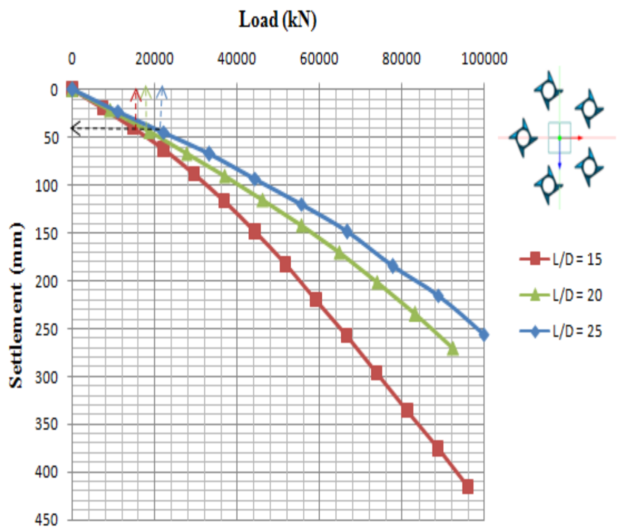
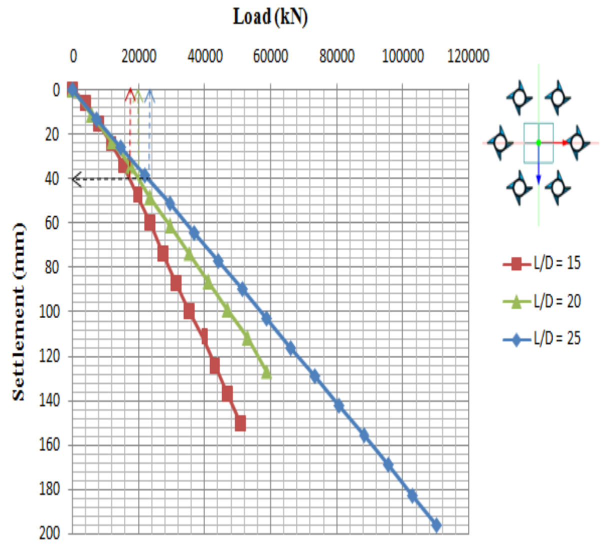
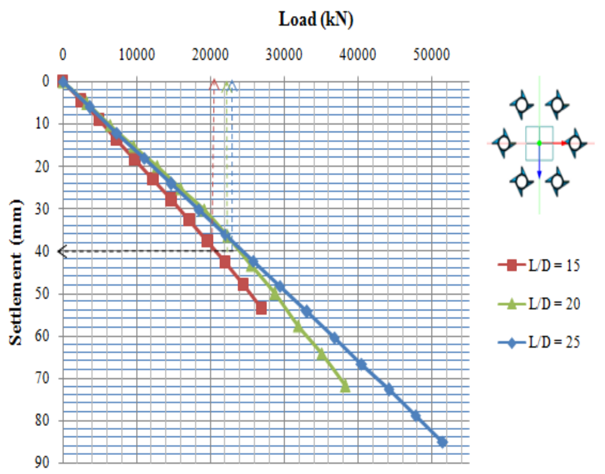


(b)

Fig. 7: Load vs. Settlement Curves for Five Spin Fin Pile for Vertical Loading in (a) Loose Sand (b) Medium Dense Sand



(a)



(b)

Fig. 8: Load vs. Settlement Curves for Six Spin Fin Pile for Vertical Loading in (a) Loose Sand (b) Medium Dense Sand

In this current study, the fin efficiency was observed by varying the slenderness ratio i.e length of the pile. The slenderness ratio varied from L/D =15 to 25, so that performance of long-pile as well as short-pile could be analyzed. The variations of load – settlement with different L/D ratio for relative density (Dr = 40% and 55%) are shown in Fig. 3 - 8. It can be observed that vertical load carrying capacity of both piles in dense sand is more than piles in loose sand. Results verify that the ultimate lateral load increases with an increase in relative density.

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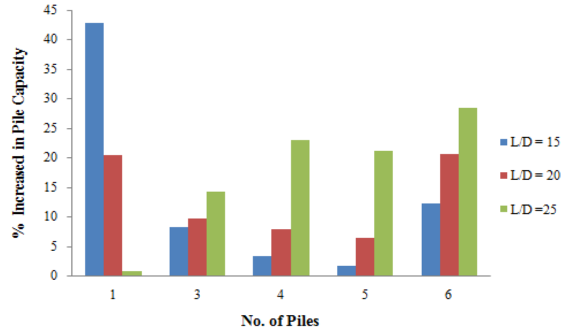

Fig.9: Variation of Slenderness Ratio versus % increase in Pile Capacity for Loose Sand.

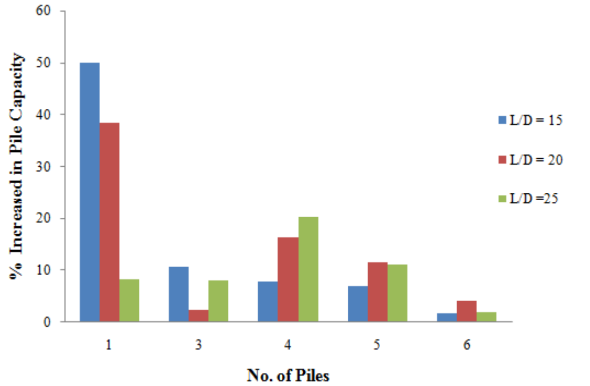

Fig.10: Variation of Slenderness Ratio versus % increase in Pile Capacity for Medium Dense Sand.

The results obviously showed that load effectiveness depends on pile stiffness. It can be seen that any increase in pile length leads to a gradual increase in load. Fig. 9 and 10 show the % increase in triangular shape spin fin pile capacity compared with conventional circular piles in loose and medium dense sand for various slenderness ratios. It can be noticed from the figures that triangular shape spin fin piles provide considerably higher ultimate vertical loads compared with a conventional circular pile.

V. CONCLUSIONS

The behaviour of circular pile and triangular shape finned piles subjected to a vertical load condition in sand deposits for different relative densities was investigated through three-dimensional nonlinear finite element analyses. The results obtained from numerical analyses were compared. Based on the investigations the following main conclusions can be drawn:

- Triangular shape spin fin piles provide considerably higher ultimate vertical loads and resistance compared with a conventional circular pile.
- Ultimate vertical load capacities of spin fin pile in dense sand is more than piles in loose sand.
- The vertical resistance increases with the increase in slenderness ratio for both loose and medium dense sand.
- The ultimate vertical load capacities of conventional circular pile and triangular shape spin fin pile increases with increase in number of piles.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support provided by the NDF AICTE–India.

REFERENCES

[1] Sakr. A. M "Model study on the performance of single-finned piles in clay under lateral load", Arabian Journal of Geosciences, pp 13-172, 2020.

[2] Panaj bariker "Study on lateral resistance of finned piles in sands. and book", Advances in Offshore Geotechnics, Proceedings of ISOG2019, pp.319-336,2020.

[3] N. G. Tale, Dr. A. I. Dhatrak and Prof. S. W. Thakare "Numerical Analysis of Spin Fin Pile under Different Loading Conditions", International Journal of Technical Innovation in Modern Engineering & Science, e-ISSN: 2455-2585 Volume 5, Issue 05,2019.

[4] Prof. S. W. Thakare, P. P. Wankhade and Dr. A. I. Dhatrak "Experimental Investigations on Performance of Spin Fin Pile under Different Loading Modes", International Journal of Technical Innovation in Modern Engineering & Science ,e-ISSN: 2455-2585, 2019.

[5] K.V. Babu and B.V.S. Viswanadham "Numerical Investigations on Lateral Load Response of Fin Piles", Springer International Publishing, DOI 10.1007/978-3319-61905-7_27, 2018.

[6] Steven Halcomb, Sean Sjostedt, and Charles Somerville "High Strain Dynamic Testing of Spin Fin Piles", ASCE, 2018.

[7] W. R. Azzam and A. Z. Elwakil "Model Study on the Performance of Single-Finned Pile in Sand under Tension Loads", International Journal of Geomechanics, ASCE, ISSN 1532-3641, 2017.

[8] Rekha Ambi, Jayasree P. K. and Unnikrishnan N. "Effect of Fin Length on the Behavior of Piles under Combined Loading Conditions", Indian Geotechnical Conference,2017.

[9] Rohan R. Deshmukh and V. K. Sharma , "Three Dimensional Computer Simulation of Cushion-Taper Finned Pile Foundation for Offshore Wind Turbine" Extended Abstract Volume of International Geotechnical Engineering Conference on Sustainability in Geotechnical Engineering Practices and Related Urban Issues,2016

[10] K. Madhusudan Reddy and R. Ayothiraman "Experimental Studies on Behavior of Single Pile under Combined Uplift and Lateral Loading", Journal of Geotechnical and Geoenvironmental Engineering, ASCE, ISSN 10900241/0401503,pp10-15,2015.

[11] Ahmed M.A. Nasr, "Experimental and theoretical studies of laterally loaded finned piles in sand" Can. Geotech. J. 51: 381–393,2014.

[12] Britta Bienen, Jan Dührkop,Jürgen Grabe, Mark F. Randolph and David J. White , "Response of Piles with Wings to Monotonic and Cyclic Lateral Loading in Sand" ,Journal Of Geotechnical And Geoenvironmental Engineering ASCE,2012.

[13] Zekkos, D, "State of the art and practice in Geotechnical Engineering", Oakland, California. ASCE, GSP226, pp. 305– 314,2012.

[14] J.-R. Peng, M. Rouainia and B.G. Clarke , "Finite element analysis of laterally loaded fin piles", Computers and Structures 88,pp 1239– 1247,2010.

[15] Jan Dührkop and Jürgen Grabe , "Laterally Loaded Piles With Bulge", Journal of Offshore Mechanics and Arctic Engineering, Vol. 130,pp 1602-04,2010.

[16] Bureau of Indian Standards, Indian Standard code for design and construction of pile foundations — code of practiceis: IS 2911 (Part 4) :2013.

[17] Spin fin pile broucher.

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A Review on Durability Aspects of Self Compacting Concrete

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Abstract— ***Self-compacting concrete (SCC) delineate one of the most considerable advances in concrete technology for ages. SCC can be produced using standard cement and additives. It consists mainly of cement, coarse and fine aggregates, and a filler, such as fly ash or super-pozzolana, water, super plasticizer and stabilizer. SCC can be representing as a high-performance material which flows under its own weight without requiring vibrators to achieve consolidation by complete filling of formworks even when access is hindered by narrow gaps between reinforcement bars. The study of solidify the effect of fiber type and aggregate acquiescent on hardened and durability properties of self-consolidating concrete and using different packing factors of sand to all aggregate ratios moreover normal and high strength of concrete grade of properties i.e. compressive, split-tensile and flexural, impact test are conducted for measuring hardened properties of concrete mixtures absorption, desorption, acid attacks, resistivity potential and chloride diffusion and also durability test carried out in the present study. The use of distinct mineral plasticizers additives and aggregate plays important role in SCC including mechanical and durability properties widely investigated. It is investigated the impacts of calcium stearate(cs) as a damp proofing agent on durability properties of SCC which were prepared with cementitious material.***

Index Terms— ***Self-compacting concrete, Durability, Transport properties, fresh properties superplasticizers.***

I. INTRODUCTION

Self-compacting concrete (SCC) is an innovative concrete that does not demand vibration for fixing & compaction it is able to flow under its own weight overall filling formwork and achieving full compaction even in the presence of congested reinforcement. The hardened concrete is dense. Homogenous and has the same engineering properties and durability as traditional vibrated concrete. The durability of concrete is also increased the industrial bio-product or waste material such as limestone powder, fly ash, granulated blast furnace slag is generally used as mineral admixtures in SCC. Besides the economical benefits uses of bio-product or waste material in concrete reduce environmental pollution. Fly ash is an industrial bio-product generated from the combustion of coal in the thermal power plants the increase scarcity of raw materials and the urgent need to protect the environmental against the pollution.

SCC requiring no gathering work at site or concrete. Plants has been developed in japan to improve the durability and uniformity of concrete. There is no standard method for SCC mix design and many academic organizations as well as admixture ready-mix precast and contracting companies have developed their own mix proportioning method. These studies show the gain of mineral admixtures uses in SCC such as reform workability with reduced cement content since cement is most expensive component of concrete.

The necessity of this type concrete was proposed by Okamura in 1986. Studies to develop self-compacting concrete (SCC), including a basic study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo. Therefore, the objective of this paper is to review the study of self-compacting concrete containing innovative material and to compile them in such a way that it would be beneficial for selection of best material.

This paper is aimed to analyze the recent researches related to the development and use of SCC comprehensively and draws a series of important conclusions based on analysis.

II. LITERATURE REVIEW

C. Vaidevi, T. Felix kala (2019) have studied that, The usage of river sand in concrete affects natural resources and groundwater. This the paper deals the discontiguous testing methods to test high-flow ability, resistance against segregation, and passing ability of self- compacting concrete for M60 grade of concrete with a partial substitution of marble waste as a fine aggregate. Slump flow, V-funnel, L-box and U-box tests were carried out to check up the performance of fresh state SCC. In hardened state, the tests were conducted and cured at different duration to find compressive strength, tensile strength and flexure strength test with the replacement of marble fine aggregate percentage of 0%, 25%, 50% and 100% in SCC for 14, 28 and 56 curing days. The chemical admixture super plasticizer master Glenium sky 8233 and the viscosity modifying agent are used. The specimens are infusion with 0.28 water-powder ratio. And also, durability of SCC is tested by RCPT, WPT, chemical attack tests like acid and sulphate attack are directed at the age of 28 and 56 days in SCC specimens. The results are compared with the conventional SCC and found satisfied up to 25% of partial replacement of fine aggregate as a marble aggregate for 28 and 56 curing days.

Wei-Ting Lin (2019) Evaluated the impact of sand/aggregate (S/A) proportion on the flowability, strength, durability, and the fine structure of self-compacting concrete (SCC). Testing was performed on sample using five S/A ratios: 51%, 52%, 53%, 54%, and 55%. Slump flow tests, slump tests, and box tests were used to designate the rheological properties of the concrete as well as the mechanical properties, together with compressive strength, splitting strength, slant shear strength and ultrasonic pulse velocity. immovability was evaluated using tests of absorption, resistivity and initial surface absorption. Microstructures were investigate using mercury intrusion porosimeter (MIP) and scanning electron microscopy (SEM). The test outcome indicates that a higher S/A ratio improved flowability. A greater proportion of coarse aggregate (i.e., a decrease in S/A ratio) developed the mechanical properties by 10% compared to the control sample (S/A ratio: 52%) at 56 days. A higher S/A ratio was shown to improve bonding capacity by enhancing the roughness of the particles and thereby increasing connection strength. A higher S/A ratio was also shown to progress the immovability of the sample by permitting denser packing; however, a higher S/A ratio resulted in a thinner interfacial transition zone. MIP analysis did not reveal a correlation during S/A ratio and the interfacial transition zone, whereas SEM photos designated that a lower S/A ratio lower the size of the interfacial transition zone.

Tao Jiang, Dawn E. Lehman (2019) This study aims to maximize the content of subsidiary cementitious material (SCM) and recycled concrete aggregate (RCA) in self-compacting concrete (SCC) by using a blending of fly ash, slag and silica fume. A level to maintained at certain rate the SCC was introduced by substantially substituting natural aggregates with RCA and cement with SCM. A total of 23 mixes, accompanied binary, ternary and quaternary mixes were active. Binary mixes were active with fly ash and ternary mixes were active with fly ash and slag. Quaternary mixes were combination with fly ash, slag, silica fume. The mechanical and durability character were measured. The effect of RCA and SCM was find out as well as using a groupism of fly ash, slag and/or silica fume. The test results indicate that the proposed groupism of fly ash, slag and silica fume can compensate for the detrimental effect of RCA and significantly progress the mechanical and durability properties of SCC with RCA, thus repair the sustainability performance of SCC by cut down cement and natural resources contended.

Zine El-Abidine Laidani, Rajab Abousnina (2019) have studied that with the present-day focus on able to maintained development in the civil engineering field, it is essential to evolve construction and building materials with reasonable costs and low environmental impacts in order to lower CO2 emissions during the production of concrete, and from the cement industry as a whole. This research studies the impact of using calcined bentonite (CB) as partial substitution of Ordinary Portland Cement (OPC) on the sustainability of self-compacting concrete (SCC). The cement in SCC mixes has become replaced with two several types of CB at 0, 5, 10, 15, 20, 25 and 30% by weight. Slump flow, V-funnel flow time, L-box test and sieve stability tests are performed to estimate the fresh properties of SCC mixtures. different tests are used to define the performance of SCC mixtures in hardened states, such as compressive strength, porosity accessible to water, chloride-ions penetration and gas permeability. The outcome showed that the use of CB in SCC mixes lowers the fresh properties of SCC and the slump flows, flow times, and segregation tests are good enough for SCC manufacture. At a hardened state, SCC with 10–15% of CB had a higher compressive strength up to 90 days, as well as improved porosity, chloride-ions penetration and gas permeability properties. These outcomes indicate that a CB solution will reduce CO2 emissions and make durable and eco-friendly SCC at a low cost.

Andressa F. Angelin, Luisa A. Gachet (2020) *have* examined that during the last 10 years, the used of distinct mineral, plasticizing additives, and aggregates into self-compact concrete (SCC) has been widely investigated. A self-compact lightweight concrete (SCLC) is produced using porous aggregates, while a self-compact rubberized concrete (SCRC) includes rubber-based contents into composition. Interesting properties such as high fluidity and cohesion, low density and as mechanical strength are attained. This investigation is focused on the development of a SCLC with expanded clay content, and five distinct mixtures are proposed. Based on the attained efficiency factor results (i.e., compressive strength per specific mass), the mixture for the production of self-compacting lightweight rubberized concrete (SCLRC) is selected. Three different percentages of utilized sand, i.e., of about 5, 10 and 15% (in mass) are replaced with the waste-tire rubber contents. The obtained fresh and hardened properties and a cost analysis are discussed. It is found that both the fresh properties and interfacial transition zone (ITZ) of the concrete matrix are improved. The cohesion between paste and particles is improved, while the rubber content decreases the density. It is induced that a environmental friendly aspect associated with economical feasibility is attained.

Nikita Gupta, Rafat Siddique (2019) In this paper, research was conducted to investigate the execution of copper slag in self-compacting concrete (SCC) pertaining to fresh and hardened parts. In this study, natural sand was replacement with 0–60% copper slag giving an progress of 10%, cement content was fungible with 20% fly ash and rest all other parameters accompanied the w/c ratio and amount of super plasticiser remained static. Fresh competence suitable the test for passing ability, flowability and the viscosity of SCC. Compressive strength was directed to test the mechanical competence of SCC. Water absorption, rapid chloride penetrability and sorptivity test were considered to assess the durability aspects of SCC for up to 1 year. To validate the experimental results, linear expulsion was applied to develop connections between fresh, strength and durability competence. The scanning electron microscopy technique was used to study the microstructure of concrete besides X-ray diffraction dissection and energy distributing spectroscopy. Method of dissection of variance (ANOVA) was rated to study the statistical prominent of the test results of compressive strength and durability properties of SCC. The fresh competence develops as the amount of copper slag increased. The results of compressive strength and durability directed considerable increase in SCC mixes containing up to 30% copper slag; beyond which the results were proportion to that of control concrete mix. This study hinted that copper slag is a defended material which could be used in SCC mixes.

Ghasan Fahim Huseien, Kwok Wei Shah (2019) Investigated that, the geopolymer with alkali activation binders are proposed as alternative environmentally friendly structure materials to the ordinary Portland cement for solving the carbon dioxide ejaculation and high energy expenditure problems. In the building sectors worldwide, the durability of concrete is the major concern. Concretes offered by recapitulate the agricultural and industrial wastes were shown to be environmentally friendly with renovate durability performance. In this view, present paper look into the effects of fly ash (FA) as substitution agent to GBFS on the durability performance of conjunction discontiguous self-compact alkali-activated concrete (SCAACs). Six concrete mixes each with a benefit of FA (30, 40, 50, 60 and 70%) in place of GBFS were formation. A control mixture with 100% GBF satisfied was used as base specimen to similitude other five mixes. competence such as filling and passing faculty, compressive strength, drying shrinkage, carbonation depth and opposition to sulfuric acid were measured. The life cycle of moved SCAACs were assessed in terms of CO2 ejaculation, cost and saving energy. The relapse and the workability of the SCAAC mixtures were repaired when FA was replacement with GBFS at 40%, 50% and 60%. Addition of FA could largely increase the SCAACs durability and present superior performance against sulphuric acid attack. Likewise, concrete mixtures containing FA of 50% and above showed shortage in CO2 ejaculation over 20%, cost about 15% as well as energy circulation almost 18%. It was concluded that by replacement GBFS by FA a potential solution to the issue of trying to reduce CO2 ejaculation and share to a healthier environment can be cognizable.

Jyothi Kumari Ganta, Seyed Sina Mousavi (2018) This study purpose to negotiate the effect of fiber type and aggregate concernment on hardened and durability parts of self-consolidating concrete. Steel, glass, and steel/glass hybrid fibers are tested in the limit experimental program. Additionally, the impact of aggregate acquiescent is considered by using apart packing factors and sand-to-all aggregate ratios. Moreover, normal and high strength concrete grades are ripe. Compressive, splitting tensile, flexural, and impact tests are conducted for measuring hardened cretic of concrete mixtures. Absorption, desorption, acid attack, resistivity, potential, and chloride diffusion are also durability tests carried out in the prefabricated study. Results show that 1.0% and 0.05% are the bronzer dosage of steel and glass fibers serially. Results show that packing factor plays a crucial role in mechanical indications of fiber-reinforced self-consolidating concretes so that an exquisite value of 1.12 and 1.14 is obtained for mechanical competency. Also, experimental results reveal that for 1.12 packing factor, the sand-to-all aggregate rate needs to be identical to the value of 0.50, while 0.57 is achieved as an optimum value for packing factor of 1.14. Overall, consequence show that hybrid-reinforced self-consolidating concrete is hopeful for mechanical and durability execution as compared to other mixture.

Ali H. Nahhab, Ali K. Ketab (2019) The studies have shown that, the impact of maximum size of aggregate (dmax), light expanded clay coarse aggregate (LECA) content, and volume fraction of micro steel fibres (Vf) on the properties of self-compacting lightweight concrete (SCLWC) were examined. A total of 18 blends with dmax of 10, 14, and 20 mm, LECA contents of 50% and 100%, and Vf of 0.25, 0.5, and 0.75% were prepared. The find out fresh character were fresh density, slump flow, T50 cm, V-funnel flow time, and L-box height ratio, while the investigated hardened properties were compressive strength, flexural strength, oven dry density, water sorptivity, drying shrinkage and load harm. The outcome apparent that increasing dmax led to decrease the superplasticizer dosage expected to keep the slump flow at 700–750 mm. The dmax of 10 mm gave the optimal compressive and flexural strengths. The water sorptivity was generally spanking as the dmax, LECA content, and Vf increased. The drying shrinkage, on the other hand, was generally reduced with increasing dmax and Vf.

Ramin Naseroleslami, Mehdi Nemati Chari (2018) Investigated that, The *Moisture* and aggressive ions devolution into concrete can be considered a prominent threat to the durability of self-consolidating concretes (SCCs). To conditioned moisture and aggressive ions devolution into concrete, utilizing damp-proofing agents is requisite to be profitable. These admixtures can decrease penetrability of concrete, especially the penetrability under non-hydrostatic condition, by providing a water-repellent layer along the capillary pores. This study detects the impacts of calcium stearate (CS), as a damp proofing agent, on durability parts of SCCs which were prefabricated with various types of supplementary cementitious materials (SCMs). In addition to durability competence, the effects of CS on mechanical indications and competence of fresh concrete, and microstructure have been studied as well. The outcomes demonstrated that in fresh concrete, CS (up to 7 kg/m3) immediate a decrease in workability and thickness of fresh concrete without any prominent impact on slump loss. The results of hardened concrete evaluation also showed a reduction in either intimacy of hardened concrete or compressive strength. Plus, microstructure dissection showed that consolidated of CS deteriorates both the cement paste and the interfacial transient zone. although CS had a trivial impact on electrical resistivity, total water absorption, and chloride diffusivity, it was absolutely effective on penetrability of concrete under non-hydro stagnant pressure. In this regard, inclusion of CS drastically reduced the depth of capillary penetration of water in addition to short- and long-term water soaking. As a case in point, incorporation of 7 kg/m3 of CS decreased the last-mentioned parameters by serially 60%, 72%, and 40% compared to the citation mixture after 120 days of moist curing.

Sajjad Mirvalad, Ali Akbar Shirzad Javid (2020) The study has shown that, The Concrete durability enhancement plays a crucial role in the function of structures located in the Persian Gulf environment. In this study, the durability execution of self-consolidating samples (concretes and mortars) blended with Silica fume, natural zeolite, and limestone powder in the form of ternary or quaternary mixtures located in the simulated marine environment is investigated. The durability execution was examined in every exposure (splash, tidal, and swamp) and control condition. To solidify the performance of mixtures, strength, and durability competence such as compressive strength, electrical resistivity, sorptivity, porosity, chloride ion permeability, and expansion tests of mortar prisms were performed. Also, the SEM explication was used to clearness the results. The results indicated that when durability properties were considered, the quaternary NZ and SF mixtures showed foremost dynamic in every test environment. Furthermore, the performance of plain shaking concrete and mortars were also compared with plain self-consolidating mixtures, and generally, the latter resulted in a better performance than the former.

III. CONCLUSION

1. The concept of SCC has established itself as innovative material in the area of concrete technology
2. The general procedure of mix design can be adopted for SCC for various applications based on experiences in identification of suitable mix proportion. The increase in fine material increases the suitability of SCC.
3. The partial replacement of cement & fine aggregate with finer material exhibit SCC with low segregation potential as assessed by the V- Funnel Test.
4. The amount of aggregate, binders & mixing water as well as type & dosage of super plasticizer to be used are the major factors influencing the properties of SCC.
5. Slump flow, V-Funnel, L-Flow, U-Box & compressive strength test was carried out to examine the performance of SCC.
6. SCC with the mineral admixtures shows satisfactory result.
7. The usage of mineral admixtures also positively influenced the fresh properties of SCC & it was important to reduce the cost of the SCC.
8. The research focus on viscosity agent and the interaction with super plasticizer is worthwhile in SCC.

REFERENCES

1. **C. Vaidevi, T. Felix Kala, A.R.R. Kalaiyarrasi;** "mechanical and durability properties of self-compacting concrete with marble fine aggregate" in Elsevier 9 October 2019.
2. **Wei-Ting Lin**; "effects of sand/aggregate ratio on strength, durability, and microstructure of self-compacting concrete", in Elsevier 17 may 2019.
3. **Zhanggen Guo, Tao Jiang, Jing Zhang, Xiangkun Kong, Chen Chen, Dawn E. Lehman;** "mechanical and durability properties of sustainable self-compacting concrete with recycled concrete aggregate and fly ash, slag and silica fume", in Elsevier 25 January 2019.
4. **Zine El-Abidine Laidani, Benchaa Benabed, Rajab Abousnina, M. Kamal Gueddouda, El-Hadj Kadri;** "experimental investigation on effects of calcined bentonite on fresh, strength and durability properties of sustainable self-compacting concrete", in Elsevier 11 April 2019.
5. **Andressa F. Angelin, Rosa C. Ceccha Lintz, Wislei R. Osoria, Luisa A. Gachet;**" evaluation of efficiency factor of self-compacting light weight concrete with rubber & expanded clay content." in Elsevier 4 September 2019.
6. **Nikita Gupta, Rafat Siddique;** "durability characteristics of self-compacting concrete made with copper slag", in Elsevier 19 October 2019.
7. **Ghasan Fahim Huseien, Kwok Wei Shah; "**durability and life cycle evaluation of self-compacting concrete containing fly ash as GBFS replacement with alkali activation", in Elsevier 2 November 2019.
8. **Jyothi Kumari Ganta, M. V. Seshagiri Rao, Seyed Sina Mousavi, V. Srinivasa Reddy, Chandrasekhar Bhojaraju;"** hybrid/glass fiber reinforced self-consolidating concrete considering packing factor: mechanical & durability characteristics." in Elsevier 3 December 2019.
9. **Ali H. Nahhab, Ali K. Ketab;**" influence of content and maximum size of light expanded clay aggregate on the

fresh, strength & durability properties of self-compacting light weight concrete reinforced with micro steel fibres.” in Elsevier 22 August 2019.

10. **Ramin Naseroleslami, Mehdi Nemati Chari;**” the effect of calcium stearate on mechanical and durability aspects of self-consolidating concretes incorporating silica fume/natural zeolite.” in Elsevier 27 October 2018.

Ductility Behaviour of Reinforced Concrete Beam-Column Joint

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***Abstract*— A beam column joint is critical zone in a reinforced concrete moment resisting frame. It is subjected to large force during severe ground shaking and its behavior has a significant influence on the response of the structure if the ductility is low resulting dangerous failure of the structure so for increasing ductility of conventional beam column joint using IS code 13920:1993 and providing ductile reinforcement according to ductile detailing of reinforcement beam column joint and also study of the difference between maximum load, ductility factor, displacement ductility.**

The dimension of beam column joint 700mm*700mm with their c/s 200mm*100mm. M30 grade of concrete will be used for casting the specimen.

***Keywords*— Beam column joint, LVDT, Data logger, bond, shear, ductility reinforcement, maximum load, ductility factor, displacement ductility.**

I. INTRODUCTION

Beam-to-column connections are designed to ensure the plastic hinge formation in the connection or in the beam, thus avoiding plastic deformations of the columns. This requirement is fulfilled by varying the connection components characteristics.Concrete loses its tensile resistance after the formation of multiple cracks, so variation of spacing in web reinforcement to concrete has been shown to increase in ductility and energy absorption capacity. Beam column joint is a typical lateral and vertical load resisting member in reinforced concrete structure The beam column joint is a crucial zone in reinforced concrete moment resisting frames. Reinforced concrete frames must perform satisfactorily under severe load conditions to withstand large lateral loads preferably without irreparable damage. It is commonly accepted that it is uneconomical to design reinforced concrete structures for the greatest possible force or force combination. Therefore, the need for strength and ductility has to be weighed against strength and economic constraints. Ductility is an essential property of structures to respond elastically during the action of devastating forces, in particular the seismic forces. Ductility is defined as the ability of sections, members and structures to deform in elastically without excessive degradation in strength or stiffness. The most common and desirable sources of inelastic structural deformations are rotations in potential plastic hinge regions.

II. OBJECTIVES

The following are the objectives carved from the literature review and gap analysis

a) To compare the test results of conventional RC beam column joints and ductile reinforcement beam column joints
b) To study the ductile behavior of RC beam column joint.
c) To design and analyze the RC beam column joint with ductile reinforcement as per IS 13920:1993.
d) To find the stiffness factor and ductility factor from load displacement curve.

III. METHODOLOGY

A. Materials

Cement, sand, bricks and iron rods(which are used to make the steel moulds).

CEMENT

Portland pozzolona cement of 53 grade is used for the investigation.

FINE AGGREGATE:

Locally available fine aggregate are used in the investigation.

COARSE AGGREGATE:

Locally available coarse aggregate are taken and sieved to the required quantity of volume to the maximum nominal size of 20 mm Care is taken to arrive the size of coarse aggregate ranging from 4.75 mm to the maximum nominal size of 20 mm.

WATER:

Potable water is used for mixing the concrete and curing the specimen.

B. Preparation of steel mould

In this project the two specimens were used for casting all the specimens consists of mould prepared with sheets of 3mm thick plates with beam cross section of 100×200×500 and column cross section of 100×200×700 and connected using bolts and nuts.

Fig 1: Preparation of mould

C. CASTING OF CUBES AND BEAM COLUMN JOINT

Cement	Fine aggregate	Coarse aggregate	Water
380 Kg/m^3	749.63 Kg/m^3	1022.28 Kg/m^3	186 lit/m^3
0.44	1	1.77	2.42

Table: 01 Mix Design for M30

Fig-2-Cubs of M30 mix ratio

Fig-03-Reinforcement details of beam column joint

a) Preparation of formwork- The wooden moulds was arranged properly and placed over a smooth surface as shown in fig.2 (a). The inside portion and corners of the moulds were properly greased for easy detachment of formwork from specimen. The Reinforcement cages were placed in the moulds and cover between cage and form kept as 15mm.

Fig-04- Casting of specimen

Mixing of concrete and casting specimen- Mix details are shown in Table 2. The concrete constituents such as cement, fly ash, fine aggregates, coarse aggregates, water, were weighed accurately and mixed. Mixing was done in pan mixer and mixing was continued until a homogeneous mixture obtained. The concrete was placed into the mould immediately after mixing. Control cubes and cylinders were casted for all the mixes. The test specimens were demoulded from mould at the end of 24 hours and cured under wet gunny bags for 28 days as shown in fig. 2(b). After curing specimens were painted with white color for proper visualization of crack pattern as shown in fig.

IV. DETAILS OF EXPERIMENTAL PROGRAMME

g) Experimental set up- The specimens were tested under a loading frame of 200 kilonewton capacity is provided in the laboratory for conducting the study on Structural elements. The LVDT (Linearly Variable Differential Transformer) displacement indicator, proving rings, dial gauges and linear variable displacement transducers are available to study failure characteristics of specimens. The 40 channel digital control system for monitoring strain measurements on line during the experimental Investigation.A point load was applied to the beam end at a distance of 50 mm from free end. Load was applied in downward direction. The load-deflection curve has been plotted by using data acquisition system. The accuracy of the deflection values were 0.01mm. For every increment of load, the surface was checked for any visible cracks and if any were marked using a marker pen. First crack width was measured immediately when crack appeared at surface of the specimen, further crack propagation was measured for each interval of load and finally, maximum crack width was measured at ultimate deflection. Test was continued till the specimen reached its ultimate failure

Fig-05: Testing of Beam-column joint

The self-straining load frame and the Hydraulic loading jack along with Load cell are arranged in such a way to apply the concentrated force over the centre of the beams specimen Care is taken to avoid eccentricity during loading. Linear Variable Differential Transformer (LVDT) is mounted where the deflections are required in the specimen. Beams are placed on loading frame and subjected to central concentrated force and the corresponding deflections are measured within the elastic range using data logger.

DETAIL ABOUT 20 CHANNEL DATA LOGGER

Measurement of physical parameters like load, pressure, linear dimensions, and vibration quantities such as acceleration , velocity frequency , and strain induced in structures, temperature, relative humidity ,ION concentration etc. are required to be made precisely and accurately for many process industries and control applications .most of these

quantities were measured in earlier days purely by mechanical means and methods .the measurements were tedious and cumbersome to make and the results were usually available in visual from like a pointer needle moving over a graduated dial only .

Fig-06-Hydraulic Jack

V.RESULTS AND DISCUSSION

Experimental Results of beam column joint as per the recommendations of IS456-2000 and *IS code 13920:1993 were drawn for Specimen 1, 2 & 3 (CJ1, DJ1 &DJ2).*

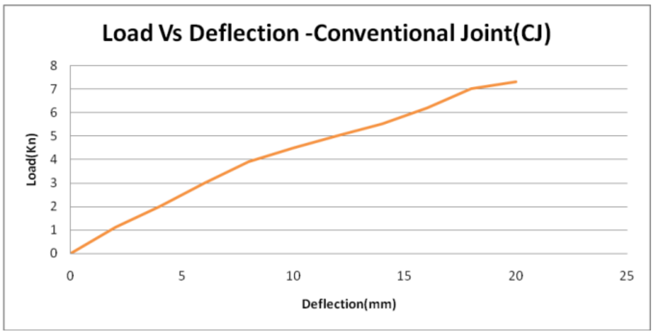
The specimen (CJ1) Refer Table 01 & Figure 01
Shows the typical behavior of beam column joint with linear

behavior upto the development of initial crack. On further loading the specimen behavior non linearly upto the ultimate load carrying capacity.
The ductility factor for the specimen is worked out as the ratio of deflection at ultimate load to the deflection at the yield level. The yield point is defined as the first initial of the crack development in the specimen.
The stiffness of the member is slope between load and deflection was also worked out in the yielding region.
The same procedure was adopted to find the Ductility factor and the beam column joint stiffness for other two specimens (DJ1 & DJ2).

ISBN: 978-93-90214-19-8

LOAD(KN)	DEFLECTION(mm)
0	0
1.1	2
2	4
3	6
3.89	8
4.5	10
5	12
5.5	14
6.2	16
7	18
7.3	20

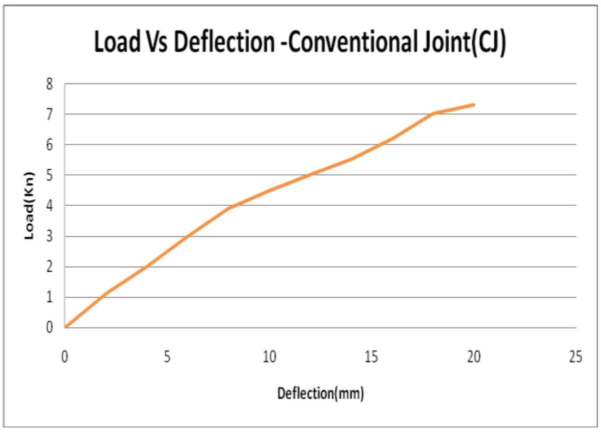
Table: 02-Load Vs Deflection for Conventional joint (CJ)



Graph-1 the -Ductility factor for conventional joint (CJ)

LOAD(KN)	DEFLECTION(mm)
0	0
1.1	2
2.5	4
3.6	6
4.5	8
5.65	10
6	12
7.2	14
8	16
8.5	18
9	20

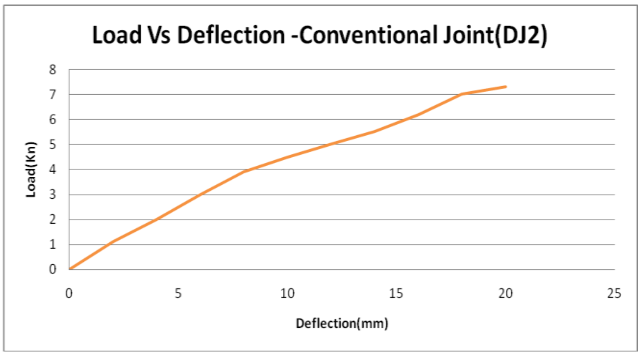
Table: 03-Load Vs Deflection for Ductile joint (DJ1)



Graph-2 -Ductility factor for conventional joint (CJ)

LOAD(KN)	DEFLECTION(mm)
0	0
1.51	2
2.53	4
3.67	6
4.59	8
5.65	10
6.3	12
7.5	14
8.213	16
8.9	18
9.2	20

Table: 03-Load Vs Deflection for Ductile joint (DJ2)



Graph-3-Ductility factor for conventional joint (CJ)

Specimen designation	Stiffness factor(KN/mm
Conventional joint	**0.384**
Ductile joint (DJ1)	**0.466**
Ductile joint (DJ2)	**0.494**

Table: 04-Stifness factor

Specimen Designation	Ductility factor(KN/mm)
Conventional joint (CJ)	**2.37**
Ductile joint (DJ1)	**3.16**
Ductile joint (DJ2)	**3.2**

Table: 06- Ductility factor

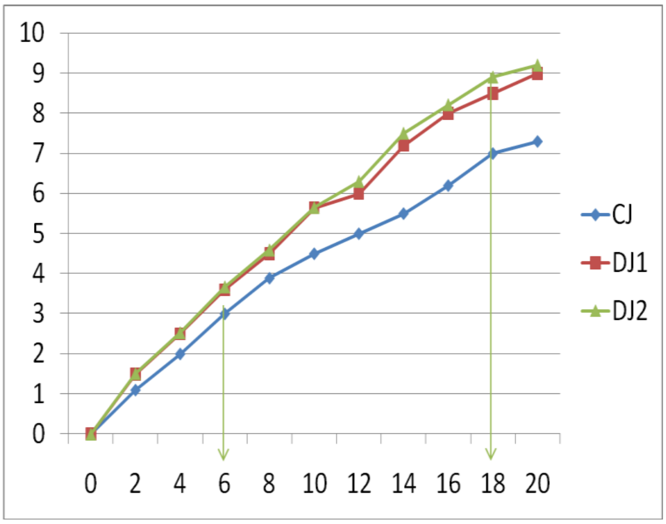


Fig-4 Comparative Load Vs Deflection

Ductility factor

Ductility of a structure is its ability to undergo deformation beyond the initial yield deformation, while still the load being sustained. Ductility can be defined as its ability to sustain inelastic deformation without loss in load carrying capacity, prior to collapse. The ductility was evaluated for core joint (CJ) and compared with ductile joint (DJ) and reference joint (RJ). The ductility factor μ, a measure of ductility of a structure, is defined as the ratio between Δ u and Δ y, where Δ u and Δ y are the respective deflections at the end of the elastic range and when the yield is first reached. Thus The value of Δ u for various specimens has been determined from the load deflection curve. After the formation of first crack, the load deflection curve takes/trying to take a plateau. The deflection corresponding to that condition has been considered as Δ u and based on this condition ductility factors have been determined. With reference to the Figure

VI. CONCLUSION

The following conclusions are drawn from the test results

1. The fundamental conclusion is that the proposed ductile joint has performed better than the conventional joint.

2. The ultimate load carrying capacity of ductile joint was found to be 21.42% more than the conventional joint.

3. The stiffness factor of ductile joint has exhibit a significant increase of 28.64% when compared with conventional joint.

4. The ductility factor of ductility joint was higher by 35.02% compared to conventional joint.

REFRENCES

[1].Bing Li(2009) , Experimental and Numerical Investigations on the Seismic Behaviour of Lightly Reinforced Concrete Beam- Column Joints, Advances in Structural Engineering Vol. 15 No. 10 2012

[2]. Mohammad Soleymani Ashtiani et al(2014) , Seismic Performance of High-Strength Self-Compacting Concrete in Reinforced Concrete BeamColumn Joints, World Conference on Earthquake Engineering, 2012

[3]Sakai and Sheik (1989) , State-of-the-art report on concrete confinement defining the status of the problem and future direction of work, ACI STRUCTURAL JOURNAL 1989

[4]Mo and Wang(2000) , Experiments on RC columns with various tie configurations by reversed cyclic loading, 1122 / JOURNAL OF STRUCTURAL ENGINEERING / OCTOBER 2000

[5]Shyh-Jiann Hwang(2004) , Seismic Design and detailing of exterior beam column joints, 13th World Conference on Earthquake Engineering

[6].A.K.Kaliluthin, et. al.(2014) , A Review on Behavior of Reinforced Concrete Beam Column Joint, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3,
Issue 4, April 2014

[7]. S. R. Uma & Sudhir K. Jain(2006), Seismic design of beam- column joints in RC moment resisting frames - Review of codes, Structural Engineering and Mechanics, Vol. 23, No. 5 (2006) 579-
597

[8].Dr.S.R.Uma and Prof. A. Meher Prasad , Seismic Behavior of Beam Column Joints in Reinforced Concrete moment resisting frames, IITKGSDMA Project on Building Codes

[9]. K.R. Bindhu, P.M. Sukumar and K.P. Jaya(2009), Performance of exterior beam column joint under seismic type loading, ISET Journal of Earthquake Technology, Paper No. 503, Vol. 46, No. 2,
June 2009

[10] .Hung-Jen Lee and Si-Ying Yu(2009), Cyclic Response of Exterior Beam Column Joints with different Anchorage Methods, ACI STRUCTURAL JOURNAL

[11]. Xilin Lu, Tonny H. Urukap, Sen Li and Fangshu Lin(2012), Seismic behavior of interior RC beam-column joints with additional bars under cyclic loading, Earthquakes and Stru Bindhu K R (2009), Behaviour of columns and exterior joints under seismic type loading,
PhD thesis at Anna Univeristy

[12] Kaviarasu(2012), Influence of joint detailing imprivementin the behaviour of precast beam column joint, ME thesis at Anna Universitz

[13] Vandhana R K, Bindu K R (2014), RCC interior beam column joint under reverse cyclic loading,World Conference on Earthquake Engineering, 2000.

[14] Shyh-Jiann Hwang, Hung-Jen Lee et. Al.(2005) , Role of hoops on shear strength of reinforced concrete beam-column joints,
Advances in Structural Engineering Vol. 15 No. 10 2012

[15] SivaChidambaram.K.R, Thirugnanam.G.S (2012), Comparative Study on Behaviour of Reinforced Beam-Column Joints with Reference to Anchorage Detailing, 1122 / JOURNAL OF STRUCTURAL ENGINEERING / OCTOBER 2000

[16] Stavroula Pantazopoulou and John Bonacci(1992), Consideration of questions about beam column joints, ACI STRUCTURAL JOUNAL,2000

[17] Sergio Malcocer(2000) , Behaviour of a precast concrete beam- column connection, World Conference on Earthquake Engineering, 2000 ctures, Vol. 3, No. 1 (2012) 37-57

18.Thomas H.-K. Kang, Myoungsu Shin, Nilanjan Mitra, and John F. Bonacci(2009) , Seismic Design of Reinforced Concrete Beam- Column Joints with Headed Bars, ACI STRUCTURAL JOURNAL

[19] Nilanjan Mitra(2007), An analytical study of reinforced concrete beamcolumn joint behavior under seismic loading, PhD thesis at University of Washington.

[20] IS 1893 (Part 1): 2002 “Criteria for earthquake resistant design of structure”.

[21] ACI 318, ― Building Code Requirements for Structural Concrete and Commentary, ‖ American Concrete Institute, USA, 2005.

[22] ACI committee 352:2002, Recommendations for design of beam column joints in monolithic reinforced concrete structures. ACI report 352R-02.

Study on Modelling & Experimental Analysis of Steel Column with Sliding Isolation System under lateral load

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Abstract – Sliding Isolation System is one of the best options to prevent the collapse of a structure during the action of lateral loading under earthquakes and wind loads. It helps to control the response acceleration transmitted to the structure under its allowable level. The system placed, laterally at two levels of the base plates, mutually perpendicular to each other which allows the oscillating movement of the structure up to a certain limit in two orthogonal directions. This helps in the dissipation of energy without causing any damage to the structure. The structure remains stationed with respect to the base plates. In this project, an I-section steel column is tested as a model, resting on a base plate using angle sections and bolted connections. The friction sliders were provided as the Sliding Isolation System at the bottom of the base plates and the lateral load was applied to the combined structure. The test results were analyzed for load and displacement under sliding base condition.

Keywords: Sliding Isolation System, orthogonal directions, base plates, friction Sliders, bolted connections.

I. INTRODUCTION

A. General

Sliding Isolation System (SIS) reduces the structural response by reduces the impact of lateral loads and dissipating the energy, thereby reducing the energy that needs to be dissipated by the structure. The ground accelerations induced large displacements at the isolator level and minimize the acceleration and story drift of the superstructure. The isolation system does not absorb the lateral load energy, but rather deflect it through the dynamics of the system. In the earthquake prone zones, there was always a need of rectification in the construction of structures to prevent them from collapses. Therefore, the use of Sliding Isolation System is needed to ensure maximum safety to the life and property during application of any kind of lateral loads. The aim of this project is to experimentally study the behavior of a sliding isolation system under a structural steel column. This system will generate a successful method to prevent the damages caused to a structure during seismic activity. A rectification to the problem has been discussed and it has been brought into the existence with an experimental way.

B. Literature Review

Lin Su et al have numerically simulated Performances of the sliding resilient-friction base isolation system for a non-uniform shear-beam structure under a variety of conditions. The sliding resilient-friction is highly effective in reducing the peak acceleration and deflection responses of the structure without generating excessively large base displacements [1]. Lin and Shenton have compared the global response of fixed-base and base-isolated structures. In both the base-isolated braced and moment frame designs, the average peak isolator displacement was less than the design bearing displacement [2]. Shenton and Lin presented the results for an isolation system with effective period equal to 2.5 sec and effective damping corresponding to 15% of critical [3]. Donato Concellara et al. have proposed High Damping Hybrid Seismic Isolator which is is obtained by the assembly in series of a Lead Rubber Bearing (LRB) and a Friction Slider (FS) with a high friction coefficient. The mathematical model is analyzed with a two Degree of Freedom System (2-DOF) in which the superstructure is assimilated to a rigid body. A dynamic nonlinear analysis is performed and the hysteretic cycles are derived and evaluated for the single components [4]. Li and Li have discussed the base isolator system with variable stiffness and damping. A new strain stiffening element has been proposed to describe the complex behavior of new adaptive base isolator [5].

II. EXPERIMENTAL INVESTIGATION

A. Specimen details

The section ISMB 100 used for the column. The angle section, with size ISA 50×50×10 used to provide support to the column. To connect angle section with the column section 2 bolts of 10 mm diameter are provided. To connect angle section with the base plate 2 bolts of 10 mm diameter are provided. Three base plates of 600 mm × 400 mm are provided for the stability of the column. Two pairs of sliders aligned under the base plate to slide in two lateral and orthogonal directions. The schematic view of the sliding isolation system is shown in Fig. 1. The fabricated model of sliding isolation system is shown in Fig. 2, 3 and 4.

Table I. Details of Specimen

Specimen	Description
Column	ISMB 100
Angle	ISA 50×50×10
Base plate	600×400 mm
Bolts	10 mm diameter
Sliders	2 pairs

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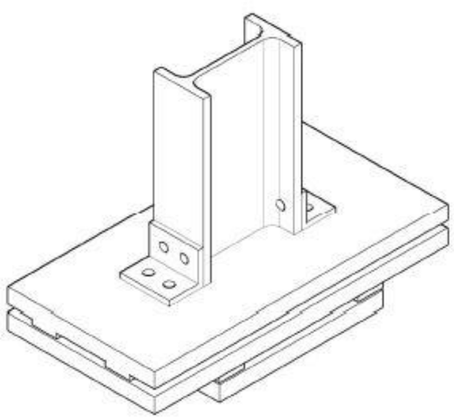

Fig.1 Proposed Sliding Isolation System

Fig.2 Fabricated Model

Fig.3 Bolted Connection in the base of column

Fig.4 Sliding Isolation System

B. Testing of specimen

The connection between the column and the base plate is made with bolted angle connection. In the loading platform, the bottom – most base plate was fixed. Over that, slider was fixed in that plate with the help of screws. This will enable for the movement in longitudinal direction. To ensure the movement in lateral direction, one more plate with slider was fixed over the base plate. To record the displacement at the top of the column, a deflectometer was placed at the top end of the column. The load was applied using 50-ton hydraulic jack at the free end of the column. The arrangement of test set is shown in Fig. 5.

Fig.5 Testing arrangement for lateral loading

Fig. 6 Position of Dial Gauge

III. RESULTS AND DISCUSSION

A. Experimental results

The tests are performed based on displacement approach. The loads are obtained corresponding to the variable displacements. The load is applied on the specimen in two different orthogonal directions. The observations are in Table II, Table III, and Table IV.

Table II. Load vs. Displacement (Trial I)

Displacement	Load Cycle - I	Load Cycle - II	Load Cycle - III
(mm)	(kN)	(kN)	(kN)
0	0	0	0
2	0.1	0.1	0.1
4	0.2	0.1	0.1
6	0.3	0.2	0.2
8	0.4	0.2	0.2
10	0.5	0.3	0.3
12	0.6	0.4	0.4
10	0.4	0.3	0.4
8	0.3	0.2	0.3
6	0.2	0.2	0.3
4	0.2	0.1	0.2
2	0.1	0.1	0.1
0	0	0	0

Table III. Load vs. Displacement (Trial II)

Displacement	Load Cycle - I	Load Cycle - II	Load Cycle - III
(mm)	(kN)	(kN)	(kN)
0	0	0	0
6	0.1	0.1	0.1
12	0.1	0.2	0.2
18	0.8	0.5	0.5
24	1.3	0.9	1.0
18	0.9	0.7	0.7
12	0.6	0.5	0.5
6	0.2	0.3	0.3
0	0	0	0

ISBN: 978-93-90214-19-8

Table IV. Load vs. Displacement (Trial III)

Displacement	Load Cycle – I	Load Cycle – II	Load Cycle - III
(mm)	**(kN)**	**(kN)**	**(kN)**
0	0	0	0
5	0.2	0.1	0.1
10	0.3	0.2	0.2
15	0.4	0.4	0.5
20	1.1	1.0	1.0
15	0.8	0.9	0.9
10	0.4	0.6	0.7
5	0.2	0.3	0.4
0	0	0	0

In the first trial, based on the displacement approach, the specimen was displaced up to 12 mm. The load was given using push pull jack. For the loading sequence, the load was pushed and the corresponding load is 0.6 kN in the cycle-1. Due to the residual displacement, for the unloading sequence the specimen was pulled. For the second trial, the specimen was displaced up to 24 mm and the corresponding maximum load is 1.3 kN. For the third trial, the specimen showed displacement up to 20 mm and the corresponding maximum load is 1.1 kN

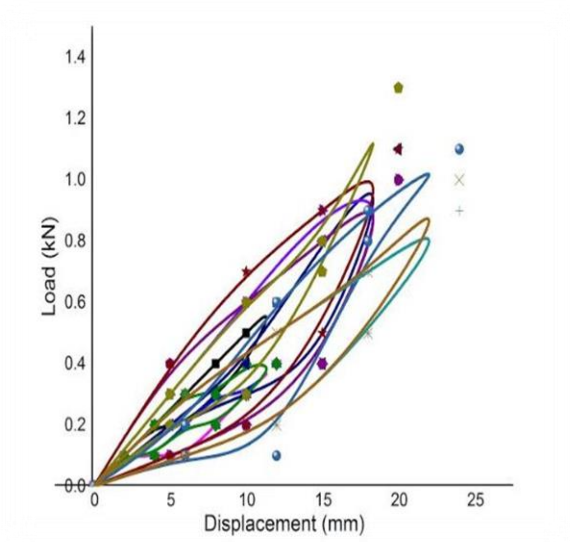

Fig. 7 Load vs Displacement of Sliding Isolation System

The above Fig. 7 shows the loading and unloading process of sliding isolation system. The curve has been drawn with the help of experimental readings and it is drawn as Load versus Displacement curve. The curve is similar to hysteresis loop within the elastic range. Due to reduction of stiffness the curve exhibited pinching effect. The energy dissipation capacity was increased steadily due to increased peak displacement without any failure.

B. Numerical calculation

The Dead Load (DL) and Earthquake Load (EL) is calculated as per IS 1893:2002 [7].

DL for 850 mm for steel section = 0.75 kN =750 N

Time period (T_a) $= 0.085\ h^{0.75}$ ... (1)

$= 0.085 \times (0.850)^{0.75}$

$= 0.075$ s

Hence, corresponding to $T_a = 0.075$ s,

The structural response factor is given as,

$\frac{S_a}{g} = 1 + 15\ T_a$ … (2)

$= 1 + (15 \times 0.075)$

$= 2.13$

Therefore, horizontal seismic coefficient,

$$A_h = \frac{ZIS_a}{2Rg} \quad \text{… (3)}$$

Z = Zone factor for Chennai (Zone–III) = 0.16

I = Importance factor = 1.5

R = Response reduction factor = 5

Therefore, $A_h = \frac{0.16 \times 1.5 \times 2.13}{2 \times 5} = 0.051\ m/s^2$

Hence, the Earthquake Loads defined as,

$EL = DL \times A_h$ ... (4)

$= 0.75 \times 0.051 = 0.038$ kN ≈ 40 N

Therefore, Design Load,

$P_d = 1.7\ (750 + 40)$

$= 1343$ N ≈ 1.35 kN

From the above calculation, it is validated that the deviation between experimental and numerical analysis 3.8%.

IV. CONCLUSION

The research aimed to generate a successful method to prevent the damages caused to a structure during seismic activity. A rectification to the problem is discussed and brought into the existence with an experimental way. It was observed that after the steel specimen with Sliding Isolation System was designed using Indian Standards and the tests were performed, the Sliding Isolation System allowed the movement of the specimen under lateral load, which helped in the dissipation of energy. But a major drawback was seen that there was a residual lateral displacement in the structure.

- The load vs. displacement curve shows hysteresis effect under the lateral load in sliding isolation system
- The maximum displacement was set at 24 mm with maximum load 1.3 kN. The deviation between experimental and numerical analysis is nearly about 3.8%.
- It can be observed that the specimen is oscillating due to the fact that the movement is allowed by the Sliding Isolation System. Due to the oscillation movement of the specimen, the energy generated by the lateral load is dissipated and hence, the final displacement has come out to be zero.
- It was found that the specimen was not experiencing any jerk due to the lateral load impact. The damage was minor in the SIS installed specimen as compared to that of the specimen without SIS.

ACKNOWLEDGEMENT

The authors of this paper would like to place on record the grateful thanks to the faculty member and non-teaching staff members of SRM Institute of Science & Technology, KTR Campus – Chennai, for providing all the facilities and their constant support & guidance in carrying out the research work.

REFERENCES

[1] Lin Su, Ahmadi Goodarz, and Tadjbakhsh Iradj GB. Performance of sliding resilient friction base-Isolation system. Journal of Structural Engineering, 1991; 117 (1): 165-181.

[2] Lin AN, and Shenton HW. Seismic performance of fixed base and base isolated steel frames. Journal of Engineering Mechanics, 1992; 118(5): 921-941.

[3] Shenton and HW. and Lin AN. Relative Performance of fixed based and base isolated concrete frame. Journal of Structural Engineering, 1993;119(10): .2952-2968.

[4] Cancellara Donato, Fabio De Angelis, Pasquino Mario. A novel seismic base isolation system consisting of a lead rubber bearing in series with a friction slider. Journal of Applied Mechanics and Materials, 2013; 256: 2174-2184.

[5] Li Y. and Li J. Base isolator with variable stiffness and damping: design, experimental testing and modelling. Proceedings of 23rd Australasian conference on the mechanics of structures and materials, Southern Cross University, Lismore, 2014.

[6] IS: 801. Cold form light gauge steel structural member in general building construction. Bureau of Indian Standards, New Delhi, 1975.

[7] IS: 1893 (Part 1). Criteria for Earthquake Resistant design of structure. Bureau of Indian Standards, New Delhi, 2002.

[8] IS: 800. Code of practice for General Construction in Steel. Bureau of Indian Standards, New Delhi, 2007.

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Structural Health Monitoring of Welded Steel Structure in Thermal Power Plants and Process Industries

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Abstract :
In most of the Coal fired Thermal Power Plants and process Industries, it is experienced that many Steel structures undergoes damages/ distresees due to ageing effects or operational environment within the life span due to various reasons. i.e. Corrosion of Steel, Pitting, undesirable vibration in the structures or due to mechanical failures etc.
For continued operation of these structures, structural monitoring are needed which involves Structural monitoring of Steel Structure. The problems encountered in each case will be unique and has to be dealt separately for each structure to the situation encountered.
In this paper, a case study is presented and discussed for the Structural monitoring of Steel Structure at Bauxite Mines using NDT techniques to minimize the damages/ failures in the structures for continued operations.
Keywords: Pitting , Corrosion

1. Introduction:

The structures in the Bauxite Mines served a life span of more than 20 years. Due to ageing effect and operational environment the authority has decided to carry out the Structural health monitoring of steel structures for continues operation to determine functional service life and structural stability and durability so that the preventive maintenance & their needed repairs/retrofits can be undertaken. It has been reported that no assessment were carried out during this period of time.

Structural Health Monitoring of steel structure is essentially required to assess the condition of the steel members by way of Non Destructive Examination/ tests to identify the distresses in the structure and its restoration for continued operation.

2. Steel Structures Identified for Examinations

1. Twin pulley trestles
2. Horizontal Twin pulley structure at drive house
2. Bend pulley structure at drive house
3. Structure of tension tower
5. Anchorage frame

3. Equipment Used For the Study:

1. Ultrasonic Thickness Gauge(Metrix UTG5)
2. MPI machine with Glow Lamps Magnetic Yok and accessories
3. Hardness machine Proseq make
4. Digital VernierCalliper (Baker ,0-150mm)
5. Manual VernierCalliper(Aerospace)
6.Manual screw gauge((Aerospace)
7.Dye Penetrant Test Kit

Fig. 1 Gravity Tension Tower

Fig.1 shows the schematic structure consist of Tension Tower built up with structural steel framework interconnected by structural ties at different levels with diagonal bracings.

The total height of Tension tower is 42m, having four vertical members of ISMB 500 having horizontal and diagonal bracings of single ISA welded with stiffener plates. The Tension Tower is erected on a solid RCC Slab.

The Winches connected on the belt tensioned roll by cable steel, directly or through a pulley arrangement. The Load cell provides the current value of belt tension to the PLC command. The PLC controls the inverter which drives the Electric motor, if the tension value is near of the upper or lower value admitted, the Electric motor rewinds or winds the cable to the proper tension. After the tension range is defined, the Winch starts to work on Automatic Operation Mode. The winch was applied instead of crane to lift up the counterweight block to relief the belt tension for maintenance events. The rope is connected to the counterbalance block by a hook connected directly to the rope through set of pulleys.

The visual observation does not indicates corrosion, pitting of structural members except at lower portion. Presently, the structure is found to be in stable condition.

4. Methodology

The methodology includes Non Destructive Testing of the Steel Structure. The method of inspection which includes inspectio of weld in structural steel should be in accordance with BIS: 822 and extent of inspection and testing shall be in accordance with the relevant applicable standarad. The results so obtained should be compared with respective standards.

Theoretical formulation

4.1 Visual inspection : Visual Inspection will be carried out to find the Settlement, Tilt rotation, distortion, Misalignment, verticality, deflection, Physical Examination, buckling/bending of structure.

4.2 Section Verification of various members of steel structure:

Linear measurement by actual measurement with vernier callipers, screw gauges, Ultrasonic thickness gauge by pulse echo method.

4.3 Dye penetration Test at weld Joints IS: 3568-1999 (Reaffirmed 2000)

This technique is adopted primarily for detection of cracks or crack like discontinuities that are open to the surface of a part, like surface porosity, pitting, pin holes and other weld defects.

4.4 Magnetic Particle Inspection at weld Joints IS 3703:2004

The technique is adopted for locating surface and sub-surface discontinuities like seams, laps, quenching and grinding cracks and surface rupture occurring on welds. This method is also used for detecting surface fatigue cracks developed during service.

Magnetic particle inspection helps to detect cracks and discontinuities on or near the surface in ferromagnetic materials.

4.5 Geometrical Properties of various members of steel structures. ASTM E 794-94

The Geometrical properties of various structural steel section i.e. Cross Sectional area, Section modulus, Moment of Inertia, Radius of gyration were evaluated from the measured the thickness or various steel members at numbers of locations.

The actual areas cross sectional area were correlated with standard members from steel tables and tabulated for assessing the distress condition due to various impacts and other deteriorating forces.

4.6 Hardness Measurement Test

The hardness number is related to the ultimate tensile strength of steel. The data are a function of the carbon content of the steel. ASTM A 370 gives a table that correlates the tensile strength to the R_B-values.

5. Test Results :

A case study for steel Struture health monitoring at Bauxite Mines is presented.

1. Visual Inspection of Steel Structure

Fig No. 2 Structural Cracks in Beam BC

Fig No. 3 Structural Cracks in Beam BC

Fig No. 4 Structural Cracks in Beam BC

2. Section Verification of steel members

Structure	Standard Sections		Measured Sections		% Reduction of section	
	Web	Flange	Web	Flange	Web	Flange
Twin pulley trestle						
Base plate20	Thick20		19.46		2.70	20.00
ISMC 250	250	80	250	79	0.00	1.25
Stiffener plate20	Thick 20		19.91		0.45	

3.Dye Penetrant test on various structural steel sections

Equipment	Visible Dye
Penetrant Make	P-Met
Cleaner make	Magna Flux/P-Met
Developer make	P-Met /Magna Flux
Dwell time	10-15 min

S. N.	Component	Location	Observations
1.	Structure of Gravity tension Tower Structure		
	Gusset Plate connection with ISMB 500 at Base foundation and stiffener Plates		No recordable indication

Fig No. 5 Structural Cracks in Beam BC

S.N.	Component	Location	Observations
1.	Structure of Anchorage Frame		
	Weld Connection Gusset plate ISMB 500 Top with ISMB 500 Bottom		No recordable indication

Fig No. 5 Structural Cracks in Beam BC

3. Magnetic Particle Inspection of weld joints on various structural steel sections

Equipment Used	Magna Flux, Wet Fluorescent/ A.C. Electromagnet
Probe spacing	8 inch for Demagnetization
Dwell time	10-15 min

S.N	Component	Location	Observations
1.	**Bend pulley structure at drive house**		
	Weld Joint connection Gusset Plate with Stiffener Plate - Vertical twin Pulley set no. 4		No recordable indication
	Welded connection ISMB 300 mounted on horizontal beam ISMB 400 Pulley Set No. 5		No recordable indication

Fig No. 6 Structural Cracks in Beam BC

4. Geometrical Properties of various members of steel structures

Structure	Actual Parameters		% reduction	
Vertical twin Pulley	Area (cm2)	M.I (cm4)	Area (cm2)	M.I (cm4)
ISMC 300	42.90	5927.87	52.33	7.67
ISA 100x100x8	14.99	144.88	2.65	0.08

6.0 Analysis of Test Result :

The Principle of Analysis of test results of NDT tests based on their correlation with the properties of Steel for the condition assessment studies

The results of various tests are utilized to assess the condition of structure in terms of defects or damges from strength and durability considerartion. Thereupon, the extent of distress and the need for re-strengthening are inferred upon.

The NDT evaluation plays a important role in maintaining the desired parameters as per standards. Based on the results of the tests, appropriate re-strengthening programme is proposed for continued operarions of these structures.

The results of Visual Inspection are utilized to assess the physical health assessment of steel structure in terms of Settlement, Tilt rotation, distortion, Misalignment, verticality, deflection, Physical Examination, buckling/bending of structure.

The results of Section Verification which consist of Linear measurement at Site and Ultrasonic Thickness with pulse echo technique of Various Structural Steel section Test are utilized to infer upon the reduction of cross sectional area and Moment of area Calculation.

The Dye Penetration Test at weld joints indicates the various weld defects in terms of
Cracks, discontinuities that are open to the surface, surface porosity, pin holes.

The Magnetic Particle Inspection adopted for locating sub-surface cracks, discontinuities in terms of seams, laps, quenching and grinding cracks and surface rupture occurring on welds.
The hardness number is related to the ultimate tensile strength of steel. The data are a function of the carbon content of the steel. ASTM A 370 gives a table that correlates the tensile strength to the R_B-values .

The Geometrical Properties of various members of steel structures i.e. Moment of Inertia, Radius of gyration were evaluated from the measured the thickness or various steel members at numbers of locations. The actual areas cross sectional area were correlated with standard members from steel tables and tabulated for assessing the distress condition due to various impacts and other deteriorating forces.

7.0 Recommendations

Based on the results of various tests, detailed analysis and Visual Inspection, the restoration programme for strengthening of structural steel members recommended to be carried out as per the technical specification and procedure for execution.

8.0 Conclusions:

The Structural health monitoring of Steel Structures was carried out successfully using Non Destructive testing of Steel. The damage/distress regions were identified and area of distresses is defined and for continued operation of these structures, the needed repairs/retrofits are suggested.

Acknowledgement :

1. Pawel Irek, Lukasz Rawicki, Karol Kaczmarek, Leszek Grolik, "Dye Penetrant Tests of Welded Joints Made in Structural Steel", Technical Report documentation.

2. Bertram Kühn, Verheyen-Ingenieure GmbH & Co. KG, Kreuznach, Germany , Technical Procedings, Procedia Engineering " Assessment of existing steel structures - Recommendations for estimation of the remaining fatigue life

3. Technical Report Documentation "Condition Assessment of Steel Structure at Bauxite Mines, Odisha.

4. Technical Report documentation October 2014 " Non Destructive Testing of Bridges by Indian Railway Institute of Civil Engineering"

Seismic Response Control of Elevated Water Tank using Base Isolation

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Abstract: A water tank is a raised design developed at a stature productive to give crisis stockpiling to fire assurance and to compress a water supply framework for the dissemination of consumable water. The raised water tank can be separated into two kinds in light of size, shape, materials and motivation behind utilize Elevated water stockpiling tank and Ground upheld tank. [4, 8] Among different design raised storage reservoir are the constructions which need to stay useful after serious quake occasion for help activity and to control fire breakouts and so forth consequently, the seismic conduct of raised tank ought to be known and perceived, and they ought to be plan to be tremor safe. [1, 17] Water is human essential need for everyday life. Raised water tank comprises of a enormous water mass at the highest point of thin organizing which are most significant thought for the disappointment of the tank during seismic tremor, raised water tanks are basic and key constructions and harm of these structures during quake may jeopardized drinking water supply. Enormous quantities of papers have been distributed till date identified with seismic reaction of raised water tank. Specialists utilize various sorts of model and scientific and test strategies to discover the seismic reaction of these constructions. Such examinations are being use to give rules and proper techniques to guarantee wellbeing of raised water tanks quite far in the occasion earthquake.[7] Elevation of the repository is given through organizing. Arranging by and large has underlying framework packing of segment and level supports which sends the heap to establishment. Water tank conduct on organizing is significant and should be assessed. In this examination, assessed seismic execution of raised water stockpiling tank by putting base confinement framework utilizing SAP2000. [19]The investigation of raised storage is performed on incautious mode and convective mode utilizing the code IS 1893(part2) and furthermore, we considered the powers in both tank full conditions and tank void condition. From this examination the powers dealing with raised water tank because of seismic powers are determined for zone IV. [18].

Key Words: Elevated Water Tank, SAP 2000, Response spectrum analysis, Base shear, Base Moment, Displacement, Time period, hydrostaticforces staging pattern.

The Indian subcontinent has a background marked by stripping seismic tremors. The significant explanation behind the recurrence and force of the quakes is that Indian plate is crashing into Asia. In numerous nations, numerous earthquakes have happened in a steady progression for 10 years. To shield structures from critical harm and reaction decrease of constructions under such extreme tremors has become a significant theme in underlying designing. [3]

1. Seismic Analysis.

Seismic Analysis is a primary examination and is the computation of the reaction of a structure construction to tremor. It is important for the cycle of underlying harm, quake designing or primary appraisal and retrofit (primary designing) in districts where seismic tremors are common. [1, 4]

A tank can possibly 'wave' to and fro during a seismic tremor (or even an extreme breeze storm). This is known as the 'principal mode' and is the most minimal recurrence of tank reaction. Most tanks, be that as it may, have higher methods of reaction, which are extraordinarily enacted during quakes. [7, 10]

Seismic analysis is needed for completing the foundational layout, underlying evaluation and retrofitting of the designs in the locales where tremors are predominant. Different seismic information is important to do the seismic investigation of the constructions. This information are available into two different ways viz. in deterministic structure or in probabilistic structure. Information in deterministic structure is utilized for plan of constructions and so forth though information in probabilistic structure are utilized for investigation of design exposed to arbitrary vibration, seismic danger examination and harm evaluation of designs under specific quake ground movement. Major seismic information incorporates ground quickening/relocation information/speed, size of quake, top ground boundaries, length and so on [1, 14]

2. Response spectrum analysis.

As per study [9, 19] Response-spectrum analysis (RSA) is a direct unique factual examination technique which quantifies the commitment from every characteristic method of vibration to show the possible greatest seismic reaction of a basically flexible design. As a component of primary period for a given time history and level of damping reaction range examination gives understanding into dynamic conduct by estimating pseudo-ghastly speeding up, speed, or relocation. It is common-sense to envelope reaction spectra a particularly smooth bend addresses the stature reaction for each acknowledgment of primary period. Reaction range examination is useful for plan dynamic since it relates primary sort determination to dynamic execution. Designs of longer period experience more noteworthy uprooting, though those of more limited period experience more prominent speeding up. During primer plan and reaction range examination underlying execution targets ought to be considered.Damping.

Damping in the convective mode for a wide range of tanks and for a wide range of fluids will be taken as 0.5% of the basic. Damping in the indiscreet mode will be taken as 2% of the basic for steel tanks and 5% of the basic for cement or workmanship tanks. [5]

3. Isolators and type of isolators.

Different examinations [1, 5] have demonstrated that viability of seismic segregation increments with the expansion of bearing adaptability and damping. With essentially less computational endeavours the proposed rough strategies precisely anticipate the pinnacle reaction of the confined raised steel tank. Assessment of greatest hydrodynamic pressing factorcoming about because of the indiscreet and convective modes demonstrated that the most extreme pressing factor happens at the lower levels of water free surface. Most extreme pressing factor happens at the lower part of full tank, since indiscreet pressing factor is prevailing in these levels. For inflexible sort tower structure the detachment framework is more viable. Mathematical and scientific estimation approaches are looked at on the case of regular tank calculation, considered the significant communication impacts. The viability of segregation frameworks for tanks increments with the ascent of the malleability of the sliding frameworks.

4. Working of Isolators.

As per study [5,10] during an earthquake Seismic base confinement of round and hollow, ground-upheld, fluid stockpiling, steel tanks has been proposed by separating the mass of the tank from the base plate and supporting it on a ring of on a level plane adaptable orientation and the base plate is upheld straightforwardly on the ground. The hole between the base plate and the divider is shut with an adaptable film which permits the divider to move openly the level way. It is seen that segregation decreases drastically then estimations of hydrodynamic toppling minutes, base shears, and the pivotal compressive anxieties in the tank without a critical expansion in free-surface sloshing. During solid ground shaking the orientation in thin tanks experience a net pliable power, since the dead weight upheld by the heading is little contrasted with the complete fluid weight. The expense saving in the even limitation, base dock, establishment and the tank material is probably going to balance altogether the extra expense of the detachment heading, adaptable layer, and the base stiffener.

5. Structural Analysis Programs.

Many studies [7-15] show that the manual procedure of seismic analysis for any structure with isolators will prove to be lengthy and time consuming. Mainly used structural analysis programs are ETABS, SAP2000, and STAAD Pro. The procedure of analysing structure with the help of such software canbe time saver. While modelling and analysing the structure, specific construction code for the analysis purpose is available in software. The software analysis procedure includes modelling of the model, assigning section and material properties, assigning load patterns and load cases. Selection of code required for analysis purpose. The analysis type includes static, dynamic, linear, non-linear, response spectrum analysis. Depending on the load cases the values of maximum base shear, absolute acceleration, absolute displacement, storey drift from the analysis obtained can be varying for different storeys. The various results obtained can be compared and then the design or data for isolation system to be used can be determined. There can be difficulty in assigning a particular analysis type for a particular damping system, to obtain the results. In the study [10] particular type of analysis to be adopted for the particular type of isolation system, which will be used is found out.

8. SAP 2000.

SAP2000 is an underlying investigation and plan programming delivered by Computer and Structures Incorporated a primary and quake designing organization. SAP2000 is a universally useful limited component program which plays out the dynamic or static nonlinear or straight investigation of underlying frameworks. It is a likewise a ground-breaking configuration device to configuration structures following AASHTO details, AISC and ACI building codes. SAP2000 is a full highlighted program that can be utilized for the most perplexing activities or the easiest issues. It includes amazing graphical UI that is unequaled regarding usability and efficiency.[19]

9. Conclusion.

The conclusions from the above studies are:

a) It is concluded that by the use of various techniques such as isolators, dampers, shear wall and bracing system seismic forces that causes base shear and overturning of water tank can be reduced.
b) Seismic response of water tank is different for different a staging pattern which is used to minimize displacement.
c) Thus, in this study we are going to use baseisolators to check the performance of tank staging during earthquake vibrations whichwill be compared with non-isolated tank.

References.

[1] Motwani, Mrs Meet. "Vibration Control of Elevated Water Tank Using Different Seismic Control Techniques–A Review."

[2] Dr..Pajgade P.S, Mr. Waghmare P. B., Dr. Kanhe N.M. "Seismic Response of Isolated Liquid Storage Tanks with ElastomericBearings."

[3] Dr. Potnis S.C., Ms. Sutar P. S. "Earthquake response of the liquid storage tank with various isolation systems."

[4] Mr. Birtharia A., Mr. Jain S. K. "Seismic response of elevated water tank."

[5] Mr. Deshmukh G. P., Mr. Patekar S. "Analysisof elevated water structure using staging system."

[6] Dr. P.S.Pajgade, Pravin B. Waghmare and Dr. N.M.Kanhe, "Seismic Response of Isolated Liquid Storage Tanks with Elastomeric Bearings (2013)."

[7] Dr. S.C.Potnis, Poonam S. Sutar, "Earthquake response of the liquid storage tank with various isolation systems(2013)."

[8] Mr. Birtharia A., Mr. Jain S. K. "Seismic response of elevated water tanks: an overview.”Neha N. Walde, Sakshi Manchalwar, Amey Khedikar, "Seismic Analysis of Water Tank Considering Effect on Time Period."

[9] G. P. Deshmukh, Ankush S. Patekar, "Analysis of elevated water storage Structure using Different staging system (2015)."

[10] Mor Vyankatesh K., More Varsha T. "Comparative study on dynamic analysis of elevated water tank frame staging and concrete shaft supported."

[11] Ankit Agarwal, "Department of Structure Engineering, Faculty of Technology UTU Dehradun, India ,Pooja Semwal."

[12] Asari Falguni P, Prof. M.G.Vanza, "Structural Control System For Elevated Water Tank."

[13] Mayank Gopal Manwani, Deepa P.Telang, "Review on seismic analysis of elevated water tank with variations of H/D ratio and container shape."

[14] Manish N. Gandhi, Ancy Rajan, "Earthquake resistant analysis of circular elevated tank with different bracings in staging."

[15] M.K. Shrimali, R.S. Jangid: "Seismic response of liquid storage tanks isolated by sliding bearings."

[16] M.B. Jadhav and R.S. Jangid: "Response of base-isolated liquid storage tanks."

[17] P.L.N.Saroja: "Comparative Study Of Analysis of Elevated Water Tank Due ToEarthquake From Different Zones Of Earthquake."

[18] Tejaswini M.S., Sridhar. R-Comparative: "Study on Behaviour of Elevated Water Tank with Soil Structure Interaction Subjected to Seismic Load Using Sap 2000."

[19] Dr. R.B. Khadiranaikar, Abbas Ali Dhundasi: "Equition For Estimation of Fundamental Time Period for Elevated Water Tank."

[20] Chirag N.Patel and H.S. Patel: "Supporting System For Renforced Concrete Elevated Water Tank: A State- Of-The Art Liturature Review."

[21] Suyash Nerkar, Chittaranjan Nayak: "Seismic Behavior Of Elevated Storage reservior By Finite Element Method."

[22] Atsushi MORI, Ryoichi Fujita, Kiyoshi Yasug, Ryoji Iso, Yuichi HAYASHI And Kenji NIWA: "A Study on a Seismic Verification and Retrofit Method for An Elevated Water Tank Against Strong Earthquaks.

Translation of Biophilia into Design of the Built Environment

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Abstract - Humans areaesthetically attracted to natural contents and to particular landscape configurations.Our affinity toward nature is genetic and deep-rooted in evolution. A strong connection to the natural environment enhances emotional well-being and alleviates feelings of social isolation.

These features are also found to have positive effects on human functioning and can reduce stress. However, opportunities for contact with these elements are reduced in modern urban life.Increasing evidences shows that creating and maintaining relationships with nature isimportant for human wellbeing. Humanity has become a mostly urbanised species wherepeople typically spend most of their time indoors. Henceit is important to explore and apply strategies fordeliberately bringing the aspects of nature into urban spaces .

This paper tries to bring forward the relationship between nature, human biology and the design of built environment. It articulates the relationship between the three elements and its design application as a way to effectively enhance health and well-being for individuals and society.

Keywords: Natural environment, emotional well- being,Biophilia, Biophilic Design

Introduction

During the 20th century, many people migrated to cities for employment and economic opportunities, abandoning farming and natural landscapes so their direct connection to the countryside and nature was lost. This process continues to this day with unprecedented urban growth.It is estimated that by 2050 almost 68% of the world population will live in urban areas. Due to the evolutionary disposition of humans, when people live in an urban habitat they will still seek to restore their lost relationship with plants and the natural world.

The concept of biophilia is formed by the combination of the words "bio" and "philia". "Bio" stands for the word "live", or "being alive" and, "philias" refers to "the attraction and positive emotions people feel for certain living spaces, actions, and beings in the natural environment" Bio means "life or living things", philia means "love". Biophilia canbe translated to Love to life.

The term 'biophilia' was first coined by social psychologist Eric Fromm (The Heart of Man, 1964) and later popularized by biologist Edward Wilson (Biophilia, 1984). In 1994, Edward O. Wilson introduced the term Biophilia for the first time, which describes the deep affiliation humans have with other life forms and nature as a whole: a connection rooted in human biology. Edward Osborne Wilson wrote the book "Biophilia" in 1984. This book proposed the deep affiliations that humans have with nature and that they are rooted in our biology. Unlike phobias and fears that people have of things in the natural world, philias are the attractions and positive feelings that people have toward certain habitats,activities, and objects in their natural surroundings. (Heerwagen 2009)"The concept of biophilia implies that humans hold a biological needfor connection with nature on physical, mental, and social levels and thisconnection affects our personal wellbeing, productivity, and societalrelationships." Sheeps Meadow, 2004Biophilia is the human affinity for natural systems. Biophilic design is design that takes our affinity for nature into consideration. Later, at the turn of the 21st century, this knowledge began to be applied, and a noticeable global trend developed in the application of biophilic design principles in the projects of numerous, internationally recognised architectural practices.

According to research, biophilic design creates healthier spaces that support wellbeing, boost creativity and focus, increase productivity, and reduce staff absence. Another factor that plays an important role in the provision of green areas and plants into the built environment is to provide cleaner air to reduce the problem of indoor air pollution.

Architect Frank Lloyd Wright had once said, "Study Nature, love Nature, stay close to Nature. It will never fail you." This famous article investigates the human-nature relationship in detail. Why we feel so empowered when we are close to Nature? What happens to us when the soft breeze or the warm sun touches us?With research-backed evidence and useful environment-support hacks, this piece explores and acknowledges the sheer boon of the 'Nature Contact'.

Human survival is dependent on ecosystems and thebiodiversity they contain (Bastian et al. 2012). This is because the diverse range of organisms inhabiting theplanet affect ecosystem processes and functions, andtherefore ecosystem services (Norberg et al. 2012, Brook et al. 2013). Ecosystem services are the benefitsthat humans (and other living organisms) derive,either directly or indirectly from the functions of ecosystems(Potschin and Haines-Young 2016). Biophilic design creates healthier spaces that support wellbeing, boost creativity, increase productivity and reduce staff absence.Adding green areas to the built environment also reduces indoor air pollution. Daylight is the best form of illumination for humans and plants alike.

INSPIRATIONS FROM NATURE

The incorporation of nature into the human environment can be found in the earliest man-made structures, and cultures around the world have found ways to bring nature into homes and public spaces. Natural objects, shapes, and processes have often acted as a source of inspiration throughout the history of architecture. The mostobvious example of this inspiration from nature is the ornaments. These ornaments often contain representations of patterns from the animaland plant world. Representations of animals and plants have long been used for decorative and symbolic ornamentation. Some architects, notably Antonı´ Gaudı´, drewlessonsfrom the structural forces governing naturalstructures, resulting in efficient and economicallybuilt architecture (e.g., Sweeney &Sert, 1960). Nature themes can beclearly found in the earliest human structures: Stylized animals characteristic of the Neolithic GöbekliTepe ; the Egyptian sphinx, or the acanthus leaves adorning Greek temples and their Vitruvian origin story; from the primitive hut to the delicate, leafy filigrees of Rococo design. Representations of animals and plants have long been used for decorative and symbolic ornamentation. Beyond representation, cultures around the world have long brought nature into homes and public spaces. Classic examples include the garden courtyards of the Alhambra in Spain, porcelain fish bowls in ancient China, the aviary in Teotihuacan (ancient Mexico City), bonsai in Japanese homes, papyrus ponds in the homes of Egyptian nobles, the cottage garden in medieval Germany, or the elusive hanging gardens of Babylon.

The consistency of natural themes in historic structures and places suggests that biophilic design is not a new phenomenon; rather, as a field of applied science, it is the codification of history, human intuition and neural sciences showing that connections with nature are vital to maintaining a healthful and vibrant existence as an urban species.

NATURE-HEALTH RELATIONSHIPS

Biophilia is the deep-seated need of humans to connect with nature. It helps explain why crackling fires and crashing waves captivate us; why a view to nature can enhance our creativity; why shadows and heights instill fascination and fear; and why gardening and strolling through a park have restorative healing effects. Biophilia, as a hypothesis, may also help explain why some urban parks and buildings are preferred over others. For decades research scientists and design practitioners have been working to define aspects of nature that most impact our satisfaction with the built environment.Much of the evidence for biophilia can be linked to research in one or more of three mind-body systems – cognitive, psychological and physiological.These have been explored and verified to varying degrees, in laboratory or field studies, to help explain how people's health and well-being are impacted by their environment.As designers and planners the Health responses are of specific interest to us because they influence how an individual might experience the designs created by us, and also understand how it influences public health and equitable access to nature and its benefits.

S.No	Mind-body systems	Nature- Health Relationship
1	**Cognitive Functionality and Performance-** Cognitive functioning encompasses our mental agility and memory, and our ability to think, learn and output either logically or creatively. For instance, directed attention is required for many repetitive tasks, such as routine paperwork, reading and performing calculations or analysis, as well as for operating in highly stimulating environments, as when crossing busy streets. Directed attention is energy intensive, and over time can result in mental fatigue and depleted cognitive resources (e.g., Kellert et al., 2008; van den Berg et al., 2007).	Strong or routine connections with nature can provide opportunities for mental restoration, during which time our higher cognitive functions can sometimes take a break. As a result, our capacity for performing focused tasks is greater than someone with fatigued cognitive resources.
2	**Psychological Health and Well-being-** Psychological responses encompass our adaptability, alertness, attention, concentration, and emotion and mood. This includes responses to nature that impact restoration and stress management.	Empirical studies have reported that experiences of natural environments provide greater emotional restoration, with lower instances of tension, anxiety, anger, fatigue, confusion and total mood disturbance than urban environments with limited characteristics of nature (e.g., Alcock et al., 2014; Barton & Pretty, 2010; Hartig et al., 2003; Hartig et al., 1991).
3	**Physiological Health and Well-being-** Physiological responses encompass our aural, musculoskeletal, respiratory, circadian systems and overall physical comfort.	Physiological responses triggered by connections with nature include relaxation of muscles, as well as lowering of diastolic blood pressure and stress hormone (i.e., cortisol) levels in the blood stream (e.g., Park et al., 2009). Short term stress increases in heart rate and stress hormone levels, such as caused by encountering an unknown but complex and information-rich space, or looking over a banister to 8 stories below, can be beneficial to regulating physiological health (Kandel et al., 2013).The inclusion of real nature is often difficult to achieve in the built environment. Friedman, Freier and Kahn (2004) hypothesized that simulated nature could have the same physiological benefits as exposure to real natural elements or environments; this was later invalidated by Kahn et al. (2008)

PATTERNS OF BIOPHILIC DESIGN AND ITS HEALTH BENEFITS

According to Cramer and Browning (2008), human-nature relationships tend to fall into three broad experience categories: nature in the space, natural analogues, or nature of the space. This provides a framework for understanding and enabling thoughtful incorporation of a rich diversity of strategies into the built environment.

The purpose of defining these patterns is to articulate connections between aspects of the built and natural environments and how individuals react to and benefit from them.

A) Nature in the Space

Nature in the Space addresses the direct, physical and ephemeral presence of nature in a space or place. This includes plant life, water and animals, as well as breezes, sounds, scents and other natural elements. Common examples include potted plants, flowerbeds, bird feeders, butterfly gardens, water

ISBN: 978-93-90214-19-8

features, fountains, aquariums, courtyard gardens and green walls or vegetated roofs. The strongest Nature in the Space experiences are achieved through the creation of meaningful, direct connections with these natural elements, particularly through diversity, movement and multi-sensory interactions.

Nature in the Space encompasses seven biophilic design patterns:

1. **Visual Connection with Nature.**A view to elements of nature, living systems and natural processes. Visual preference research by Orians and Heerwagen (1992) indicated that universally the preferred view is looking down a slope to a scene that includes copses of shade trees, flowering plants, calm non-threatening animals, indications of human habitation, and bodies of clean water. It Lowered blood pressure and heart rate Improved mental engagement/ attentiveness (Biederman& Vessel, 2006) Positively impacted attitude and overall happiness (Barton & Pretty, 2010)
2. **Non-Visual Connection with Nature.** Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes.Research by Alvarsson et al. (2010) suggested that nature sounds, when compared to urban noise, allow for physiological and psychological restoration to occur up to 37% faster. In a study relating aromatherapy and post-anesthesia care, Kim et al. (2007) reported 45% less morphine and 56% fewer analgesics used among patients who underwent aromatherapy after surgery. A study by Li et al. (2012) also found that phytoncides (essential oils from trees) had a positive effect on human immune function both in vitro and in vivo.
3. **Non-Rhythmic Sensory Stimuli.** Stochastic and ephemeral connections with nature that may be analyzed statistically but may not be predicted precisely.Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)
4. **Thermal & Airflow Variability.** Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments. An environment devoid of sensory stimulation and variability can lead to boredom and passivity.
5. **Presence of Water.** A condition that enhances the experience of a place through seeing, hearing or touching water. Clean water and naturally fluctuating water movement is preferred over predictable movement orstagnancy (Alversson et al., 2010; Biederman& Vessel, 2006). The presence of water generated greater improvements in both self-esteem and mood and reduced stress.
6. **Dynamic & Diffuse Light.** Leverages varying intensities of light and shadow that change over time to create conditions that occur in nature. Heerwagen (2006) explained that evidence has shown that people like moderate levels of sensory variability in the environment, including variation in light, sound and temperatures, (e.g., Humphrey, 1980; Platt, 1961), and that an environment devoid of sensory stimulation and variability can lead to boredom and passivity (e.g., Schooler, 1984; Cooper, 1968).
7. **Connection with Natural Systems.** Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem.This enhanced positive health responses; Shifted perception of environment (Kellert et al., 2008)

B) Natural Analogues

Natural Analogues addresses organic, non-living and indirect evocations of nature. Natural Analogues are objects, materials, colors, shapes, patterns and algorithms that evoke nature. Broadly speaking, analogues can be characterized in architecture and design as representational artwork, ornamentation, biomorphic forms and natural materials. Objects, materials, colors, shapes, sequences and patterns found in nature, manifest as artwork, ornamentation, furniture, décor, and textiles in the built

ISBN: 978-93-90214-19-8

environment. Mimicry of shells and leaves, furniture with organic shapes, and natural materials that have been processed or extensively altered (e.g., wood planks, granite tabletops), each provide an indirect connection with nature: while they are real, they are only analogous of the items in their 'natural' state.

Natural Analogues encompasses three patterns of biophilic design:

1. **Biomorphic Forms & Patterns.** Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature. This Observed view preference (Vessel, 2012; Joye, 2007).
2. **Material Connection with Nature**. Materials and elements from nature that, through minimal processing, reflect the local ecology or geology and create a distinct sense of place. This decreased diastolic blood pressure and Improved comfort (Tsunetsugu, Miyazaki & Sato, 2007) and also Improved creative performance (Lichtenfeld et al., 2012)
3. **Complexity & Order.** Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature. Complexity and order is characterized by the presence of rich sensory informationthat is configured with a coherent spatial hierarchy, similar to the occurrence of design in nature.In architecture and landscape, the experience is interpreted by S. Kaplan (1988:48) as "howmuch is 'going on' in a particular scene, how much there is to look at".While mid-range fractal dimensions may be preferred, at either end of the spectrum,Hägerhäll et al. (2008), Taylor (2006) and others have reported that high-dimensional fractalartwork and overly complex environments can result in psychological stress and even nausea.

C) Nature of the Space

Nature of the Space addresses spatial configurations in nature. This includes our innate and learned desire to be able to see beyond our immediate surroundings, our fascination with the slightly dangerous or unknown; obscured views and revelatory moments; and sometimes even phobia inducing properties when they include a trusted element of safety. The strongest Nature of the Space experiences are achieved through the creation of deliberate and engaging spatial configurations commingled with patterns of Nature in the Space and Natural Analogues.

Nature of the Space encompasses four biophilic design patterns:

1. **Prospect.** An unimpeded view over a distance, for surveillance and planning. Health benefits are benefitted to include reduced stress, reduced boredom, irritation and fatigue as well as improved comfort(Grahn&Stigsdotter, 2010, Petherick, 2000; Wang & Taylor, 2006)
2. **Refuge.** A place for withdrawal from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead. Improved concentration, attention and perception of safety (Grahn&Stigsdotter, 2010; Wang & Taylor, 2006; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)
3. **Mystery.** The promise of more information, achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment. Mystery engenders a strong pleasure response within the brain that may be a similarmechanism to that of anticipation (Biederman and Vessel E, 2006)
4. **Risk/Peril.** An identifiable threat coupled with a reliable safeguard. As per the study done by various experts it shows that this pattern resulted in strong dopamine or pleasure responses (Kohno et al., 2013; Wang &Tsien, 2011; Zald et al., 2008).

TRANSLATION OF BIOPHILIA INTO DESIGN OF THE BUILT ENVIRONMENT

It is vital for a designer to understand a project's design intent – What are the health or performance priorities of the intended users? To identify design strategies and interventions that restore or enhance well-being, project teams should understand the health baseline or performance needs of the target population.

Biophilic design patterns are flexible and replicable strategies for enhancing the user experience that can be implemented under a range of circumstances. Just as lighting design for a classroom will be different than for a spa or home library, biophilic design interventions are based on the needs of a specific population in a particular space, and are likely to be developed from a series of evidence-based biophilic design patterns, ideally with a degree of monitoring and evaluation for efficacy.

Biophilic design patterns should be scaled to the surrounding environment and to the predicted user population for the space. Patterns can be applied at the scale of a micro-space, a room, a building, a neighborhood or campus, and even an entire district or city.

S.NO	Patterns of Biophilic Design	Translation in Built Environment
1	NATURE IN THE SPACE	
	1.Visual Connection with Nature Vegetated spaces can improve an individual's self-esteem and mood, while the presence of water can have a relaxing effect. Use of local building materials, climate responsive design and xeriscaping – using native, drought tolerant plants to create landscape designs that resemble the climate of the surrounding landscape – can each be effective strategies in designing for a resilient, biophilic experience.	In Workplace and Office design the strategy should be to improve views and bring plants into the space, this can be achieved by installing a green wall, orienting desks to maximize views to outdoors, and initiating an employee stipend for desk plants. The detail, location, and the extent to which each of these interventions is implemented will/may differ for each of the offices. For Hospitals replacing the abstract art with landscape paintings on the walls of the staffroom and installing a small garden and seating area in the adjacent interior courtyard can be more effective. While this project can also use the Visual Connection with Nature pattern, the selected interventions specifically target stress reduction for emergency room nurses based on a shared space they utilize routinely. A carved out space, with good landscaping, in the middle of the building through which everybody passes while entering or leaving the building is also a very effective method.
	2. Non-Visual Connection with Nature A space with a good Non-Visual Connection with Nature feels fresh and well balanced; the ambient conditions are perceived as complex and variable but at the same time familiar and comfortable, whereby sounds, aromas, and textures are reminiscent of being outdoors in nature.	**Naturally Occurring** Fragrant herbs and flowers, Song of birds,Flowingwater,Weather (rain, wind, hail) Natural ventilation by providing operable windows and breezeways. Providing Textured materials (stone, wood, fur) , Crackling fire/fireplace, Sun patches-Warm/cool surfaces **Simulated or Constructed** Providing Digital simulations of nature sounds, Mechanically released natural plant oils,Highly textured fabrics/textiles that mimic natural material textures, Audible and/or physically accessible water feature,Music with fractal qualities,Horticulture/gardening, including edible plants, Domesticated animals/pets, Honeybee apiary etc.
	3. Non-Rhythmic Sensory Stimuli	A non-rhythmic stimuli strategy can be interwoven with almost any landscape or horticulture plan. For instance, selecting plant species for window boxes that will attract bees, butterflies and other pollinators The stochastic movement of a butterfly will capture one's attention each time, for recurring physiological benefits
	4. Thermal & Airflow Variability A space with good Thermal & Airflow Variability feels refreshing, active, alive,	Since thermal comfort is inherently subjective, and strongly varies between people, it is important to give a degree of control to individuals, access to operable windows or

	invigorating and comfortable. The space provides a feeling of both flexibility and a sense of control.	shades, access to localized and energy-efficient fans or heaters, thermostat controls etc., Designing façade and internal layouts to enhance daylight and light/shade variability while reducing glare and Connecting, elevated exterior walkways also provide access to breezes, shade and solar heat should be done.
	5. Presence of Water A space with a good Presence of Water condition feels compelling and captivating. Fluidity, sound, lighting, proximity and accessibility each contribute to whether a space is stimulating, calming, or both.	Providing small scale water bodies and the Sounds created by small-scale running water is beneficial. Vistas to large bodies of water or physical access to natural or designed water bodies and displaying Images of nature that include aquatic elements can also be provided.
	6. **Dynamic & Diffuse Light**A space with a good Dynamic & Diffuse Light condition conveys expressions of time and movement to evoke feelings of drama and intrigue, buffered with a sense of calm.	Providing diffuse lighting on vertical and ceiling surfaces, daylight from multiple angles and also differing orientations of windows, clerestories, skylights and a large central atrium allows for light to penetrate at variable levels of diffusion to create an enhanced user experience
	7. **Connection with Natural Systems-** A space with a good Connection with Natural Systems evokes a relationship to a greater whole, making one aware of seasonality and the cycles of life. The experience is often relaxing, nostalgic, profound or enlightening, and frequently anticipated.	Integration of rainwater capture and treatment into the landscape design that respond to rain events, Step wells for seasonal rainwater storage and social convergence,the incorporation of responsive design tactics (e.g., use of materials that change form or expand function with exposure to solar heat gain, wind, rain/moisture, or shading), structures (e.g., steps wells), and land formations (e.g., bioswales, arroyos, dunes) will be necessary to achieve the desired level of awareness. Wildlife habitats (e.g., birdhouse, honeybee apiary, hedges, flowering vegetation) etc can be provided.
2	**NATURAL ANALOGUES**	
	1. Biomorphic Forms & Patterns A space with good Biomorphic Forms & Patterns feels interesting and comfortable, possibly captivating, contemplative or even absorptive.	The objective of Biomorphic Forms & Patterns is to provide representational design elements within the built environment that allow users to make connections to nature. The intent is to use biomorphic forms and patterns in a way that creates a more visually preferred environment that enhances cognitive performance while helping reduce stress.There are essentially two approaches to applying Biomorphic Forms & Patterns, as either a cosmetic decorative component of a larger design, or as integral to the structural or functional design. Both approaches can be utilized in tandem to enhance the biophilic experience.
	2. Material Connection with Nature-It is material and elements from nature that, through minimal processing, reflect the local ecology or geology to create a distinct sense of place. A space with a good Material Connection with Nature feels rich, warm and authentic, and sometimes stimulating to the touch.	Natural materials can be decorative or functional, and are typically processed or extensively altered (e.g., wood plank, granite countertop) from their original 'natural' state, and while they may be extracted from nature, they are only analogous of the items in their 'natural' state.

	3.**Complexity & Order** Complexity & Order is rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature. A space with good Complexity & Order feels engaging and information-rich, as an intriguing balance between boring and overwhelming.	The objective of the Complexity & Order pattern is to provide symmetries and fractal geometries, configured with a coherent spatial hierarchy, to create a visually nourishing environment that engenders a positive psychological or cognitive response (Salingaros, 2012).It can be achieved by Wallpaper and carpet design ,Material texture and contour ,Window details: trim and moldings, glass color, texture, mullion design, window reveal detail ,Plant selection variety and placement, Complex plant oil fragrances, Auditory stimuli, Exposed structure/exoskeleton ,Exposed mechanical systems,Façade materials, Façade, spandrel and window hierarchy, Building skyline,Floor plan, landscape plan, urban grid,Pedestrian and traffic flows ,Resource flows etc.
3	**NATURE OF THE SPACE**	
	1.Prospect Prospect is an unimpeded view over a distance for surveillance and planning. The objective of the Prospect pattern is to provide users a condition suitable for visually surveying and contemplating the surrounding environment for both opportunity and hazard. A space with a good Prospect condition feels open and freeing, yet imparts a sense of safety and control, particularly when alone or in unfamiliar environments.	There are potentially endless combinations for applying characteristics of prospect (Dosen& Ostwald, 2013). There is interior prospect, exterior prospect, as well as short depth and high depth prospect that can occur simultaneously. For interior spaces or dense urban spaces, prospect is the ability to see from one space to another, and is strengthened when there are clear distinctions and the opportunity to see through multiple spaces (Hildebrand, 1991).Prospect can be achieved by Orienting building, fenestration, corridors and workstations will help optimize visual access to indoor or outdoor vistas, activity hubs or destinations,Designing with or around an existing or planned savanna-like ecosystem, body of water, and evidence of human activity or habitation will help the information-richness of the prospect view,Providing Focal lengths ≥ 20 feet (6 meters), Providing Partition heights ≤ 42 inches (hedges; opaque workplace partitions),Using Transparent materials,Providing Balconies, catwalks, staircase landings,Locating stairwells at building perimeter with glass façade and interior glass stairwell walls can form a dual prospect condition,Designing Open floor plans and Elevated planes,When high ceilings are present, perimeter or interior spaces elevated 12-18” will enhance the Prospect condition.
	2. Refuge. Refuge is a place for withdrawal, from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead. A space with a good Refuge condition feels safe, providing a sense of retreat and withdrawal – for work, protection, rest or healing – whether alone or in small groups. A good refuge space feels separate or unique from its surrounding	Refuge spaces take many forms, so understanding the context and defining the intended user experience will certainly influence design decisions. There are endless combinations of design elements that can create a quality refuge space that offers shade or protection from natural or man-made environmental conditions. **Modular refuge**: Small protection (high-back chair, overhead trellis) **Partial refuge:** Several sides covered (reading nooks, booth seating, bay window seats, canopy beds, gazebos, canopy trees, arcades, covered walkways or porches)

	environment; its spatial characteristics can feel contemplative, embracing and protective, without unnecessarily disengaging.	**Extensive refuge:** near or complete concealment (reading/telephone/ sleeping pods, meeting rooms with 3+ walls, private offices, tree houses) **Indoor refuge** spaces are usually characterized by lowered ceiling conditions. For spaces with standard ceiling heights, this may equate to approximately 18-24 inches below the main ceiling, and is often achieved through treatments like a soffit, a drop-ceiling or acoustical paneling, or suspended fabric. Light levels in refuge spaces should differ from adjacent spaces and user lighting controls will broaden functionality as a refuge space.
	3. Mystery Mystery is the promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.	A space with a good Mystery condition has a palpable sense of anticipation, or of being teased, offering the senses a kind of denial and reward that compels one to further investigate the space. This can be achieved by Curving edges that slowly reveal are more effective than sharp corners in drawing people through a space,Dramatic shade and shadows can enhance the mystery experience, Strategies that provide dark shadows or shallow depth of field could instill unappreciated surprise or fear, the speed at which users are transiting through a space will influence both the size of the aperture and the size of the subject; faster typically means bigger,Peek-a-boo windows that partially reveal Curving edges, Organically evolved mystery conditions (e.g., low maintenance gardens with winding paths) are expectedly going to change characteristics over time. These changes should be monitored as they may enhance the mystery condition, or otherwise degrade it as it evolved into a surprise condition (e.g., overgrowth of plantings leads to obscuring of depth of field).
	4. Risk/Peril Risk/Peril is an identifiable threat coupled with a reliable safeguard. A space with a good Risk/Peril condition feels exhilarating, and with an implied threat, maybe even a little mischievous or perverse. One feels that it might be dangerous, but intriguing, worth exploring and possibly even irresistible.	The objective of the Risk/Peril pattern is to arouse attention and curiosity, and refresh memory and problem solving skills. There are different degrees of risk that can be incorporated into a design depending on the intended user or the space available. The various methods are a cantilevered walkway over a sheer cliff is an extreme case, viewing a predator in a zoo exhibit may provide a greater sense of control, rock-hopping through a gentle water feature presents the risk of getting one's feet wet, Double-height atrium with balcony or catwalk, Architectural cantilevers, Infinity edges, Façade with floor-to-ceiling transparency, Experiences or objects that are perceived to be defying or testing gravity, Transparent railing or floor plane, Passing under, over or through water, Proximity to an active honeybee apiary or predatory animals, Life-sized photography of spiders or snakesetc. The element of safety must protect the user from harm while still permitting the experience of risk.

 ISBN: 978-93-90214-19-8

CONCLUSION

As more of the world's population shifts to urban settings,the need for biophilic design will become more important. In coming decades, it is projected that 70% of the world's population will live in cities. With this shift, the need for our designs to reconnect people to an experience of nature becomes ever more important, for our health and well-being.Biophilic design is not a luxury, it's a necessity. Work placewhen well-designed, spaces can reduce deficient productivity, absenteeism, loss of focus, negative mood, and poor health. Hospitalsincorporating natural elements into the healthcare industry can reduce the cost of both patient care and staffing while improving medical outcomes. Retail Spaces -the psychologically soothing and calming effect of nature can draw shoppers into stores with biophilic elements can boost sales compared to those without. Education classrooms can be strategically designed with biophilic elements to foster better test scores, optimal health, and increased learning rates. Schoolyards with natural elements can trigger mental restoration, better behavior and enhanced focus in students. For health and wellbeing of the usersit is a prime duty of all architects and planners to reconnect people to nature through biophilic design.

REFERENCES

1. Alcock, I., M.P. White, B.W. Wheeler, L.E. Fleming, & M.H. Depledge. (2014). Longitudinal Effects on Mental Health of Moving to Greener and Less Green Urban Areas. *Environmental Science & Technology, 48* (2), 1247-1255.
2. Alvarsson, J. J., Wiens, S., & Nilsson, M. E. (2010). Stress Recovery during Exposure to Nature Sound and Environmental Noise. International Journal of Environmental Research and Public Health, 7, 1036-1046.
3. Barton, J. & J. Pretty (2010). What Is the Best Dose of Nature and Green Exercise for Improving Mental Health.*Environmental Science & Technology, 44*, 3947–3955.
4. Bastian, O., Haase, D., and Grunewald, K., 2012. Ecosystem properties, potentials and services – the EPPS conceptual framework and an urban application example. Ecological indicators, 21, 7–16.
5. Biederman, I., & Vessel, E. (2006). Perceptual Pleasure and the Brain. American Scientist, 94, 248-255.
6. Brook, B., et al., 2013. Does the terrestrial biosphere have planetary tipping points? Trends in ecology & evolution, 28, 396–401. doi:10.1016/j.tree.2013.01.016
7. Cooper, R. (1968). The Psychology of Boredom. Science Journal, 4(2), 38-42.
8. Cramer, J. S., & Browning, W. D. (2008). Transforming Building Practices ThroughBiophilic Design (pp335–346). In S. F. Kellert, J. H. Heerwagen, & M. L. Mador (Eds.), Biophilic Design. Hoboken, NJ: Wiley.
9. Dosen, A.S., & M.J. Ostwald (2013). Prospect and Refuge Theory: Constructing a Critical Definition for Architecture and Design. *The International Journal of Design in Society, 6* (1), 9-24.
10. Friedman, B., Freier, N. G., & Kahn, P. H., Jr. (2004). Office window of the future?—Two case studies of an augmented window. In Extended abstracts of SIGCHI conference on human factors in computing systems (p1559). New York: ACM Press.
11. Grahn, P., &Stigsdotter, U. K. (2010). The relation between perceived sensory dimensions of urban green space and stress restoration. *Landscape and Urban Planning, 94*, 264–275.
12. Hägerhäll, C.M., T. Laike, R. P. Taylor, M. Küller, R. Küller, & T. P. Martin (2008). Investigations of Human EEG Response to Viewing Fractal Patterns. *Perception, 37*, 1488-1494.
13. Hartig, T., M. Mang, & G. W. Evans (1991). Restorative Effects of Natural Environment Experience. *Environment and Behavior, 23*, 3–26.
14. Hartig, T., G.W. Evans, L.D. Jamner, D.S. Davis, & T. Gärling (2003). Tracking Restoration in Natural and Urban Field Settings. *Journal of Environmental Psychology, 23*, 109–123.
15. Heerwagen, J. H. (2006). Investing In People: The Social Benefits of Sustainable Design. Rethinking Sustainable

Construction. Sarasota, FL. September 19-22, 2006.

16. Heerwagen, J.H., Restorative commons: creating health and well-being through urban landscapes, U.S. Depart of Agriculture, Northern Research Station:38-57. 2009 Kellert, S.R., Heerwagen, J.H., Mador, M.L. Biophilic Design: The Theory, and Practice of Bringing Buildings to Life.Hoboken, NJ: John Wiley & Sons, Inc. 2008.
17. Hildebrand, G. (1991). *The Wright Space: Pattern & Meaning in Frank Lloyd Wright's Houses.* Seattle: University of Washington.
18. Humphrey, N. (1980). Natural Aesthetics. In B. Mikellides (Ed.), Architecture for People. London: Studio Vista.
19. Joye, Y. (2007). Architectural Lessons From Environmental Psychology: The Case of Biophilic Architecture. *Review of General Psychology, 11* (4), 305-328.
20. Kahn, P. H., Jr., Friedman, B., Gill, B., Hagman, J., Severson, R. L., Freier, N. G., Feldman, E. N., Carrere, S., &Stolyar, A. (2008). A plasma display window?—The shifting baseline problem in a technologically mediated natural world. Journal of Environmental Psychology, 28, 192–199.
21. Kandel, E.R., J.H. Schwartz, T.M. Jessell, S.A. Siegelbaum, & A.J. Hudspeth (2013). *Principles of Neural Science*, Fifth Edition. New York: McGraw Hill.
22. Kaplan, S. (1988). Perception and Landscape: Conceptions and Misconceptions. In J. Nasar (Ed.), *Environmental Aesthetics: Theory, Research, and Applications* (pp. 45– 55). Cambridge, England: Cambridge University Press.
23. Kellert, S.F., J.H. Heerwagen, & M.L. Mador Eds. (2008). *Biophilic Design: The Theory, Science & Practice of Bringing Buildings to Life*. Hoboken, NJ: John Wiley & Sons.
24. Kim, J. T., Ren, C. J., Fielding, G. A., Pitti, A., Kasumi, T, Wajda, M., Lebovits, A., &Bekker, A. (2007). Treatment with lavender aromatherapy in the post-anesthesia care unit reduces opioid requirements of morbidly obese patients undergoing laparoscopic adjustable gastric banding. Obes Surg., 17(7), 920-925.
25. Kohno, M., D.G. Ghahremani, A.M. Morales, C.L. Robertson, K. Ishibashi, A.T. Morgan, M.A. Mandelkern& E.D. London (2013) Risk-Taking Behavior: Dopamine D2/D3 Receptors, Feedback, and Frontolimbic Activity. Cerebral Cortex, bht218. First published online: August 21, 2013.
26. Li, Q. (2010). Effect of Forest Bathing Trips on Human Immune Function. *Environmental Health and Preventive Medicine, 15* (1), 9-17.
27. Lichtenfeld, S., A.J. Elliot, M.A. Maier, & R. Pekrun (2012). Fertile Green: Green Facilitates Creative Performance. Personality and Social Psychology Bulletin, 38 (6), 784-797.
28. Norberg, J., et al., 2012. Eco-evolutionary responses of biodiversity to climate change. Nature climate change, 2, 747–751. doi:10.1038/nclimate1588.
29. Orians, G. H. &Heerwagen, J. H. (1992). Evolved responses to landscapes. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), The adapted mind: Evolutionary psychology and the generation of culture (pp. 555-579). New York, NY, US: Oxford University Press.
30. Park, B.J., Y. Tsunetsugu, T. Kasetani, T. Morikawa, T. Kagawa, & Y. Miyazaki (2009). Physiological Effects of Forest Recreation in a Young Conifer Forest in Hinokage Town, Japan. *Silva Fennica, 43* (2), 291-301.
31. Petherick, N. (2000). Environmental Design and Fear: The Prospect-Refuge Model and the University College of the Cariboo Campus. Western Geography, 10/11, 89–112.
32. Platt, J. R. 1961. Beauty: Pattern and Change. In D.W. Fiske & S.R. Maddi (Eds.), Functions of Varied Experience. Homewood, IL: Dorsey Press.
33. Potschin, M. and Haines-Young, R., 2016. Defining and measuring ecosystem services. In: M. Potschin, et al., eds.

Routledge handbook of ecosystem services. London and New York: Routledge, 25–44.

34. Schooler, C. (1984). Psychological Effects of Complex Environments During the Life Span: A Review and Theory. Intelligence, 8, 259-281.
35. Sweeney, J. J., &Sert, J. L. (1960). AntoniGaudı´.London: The Architectural Press.
36. Taylor, R.P., (2006). Reduction of Physiological Stress Using Fractal Art and Architecture. *Leonardo, 39* (3), 245–251.
37. Tsunetsugu, Y., Y. Miyazaki, & H. Sato (2007). Physiological Effects in Humans Induced by the Visual Stimulation of Room Interiors with Different Wood Quantities. Journal of Wood Science, 53 (1), 11-16.
38. Van den Berg, A.E., T. Hartig, & H. Staats (2007). Preference for Nature in Urbanized Societies: Stress, Restoration, and the Pursuit of Sustainability. Journal of Social Issues, 63 (1), 79-96.
39. Van den Berg, A.E., Y. Joye, & S. de Vries (2007). Health Benefits of Nature. In: L. Steg, A.E. van den Berg, & J.I.M. de Groot (Eds.), Environmental Psychology: An Introduction (47-56). First Edition. Chichester: Wiley- Blackwell. pp406.
40. Vessel, Edward A. (2012). New York University Center for Brain Imaging. Personal communication with the authors.
41. Wang, K. & Taylor, R. B. (2006). Simulated Walks through Dangerous Alleys: Impacts of features and progress onfear. Journal of Environmental Psychology, 26, 269–283.
42. Wang, D.V. & J.Z. Tsien (2011). Convergent Processing of Both Positive and Negative Motivational Signals by the VTA Dopamine Neuronal Populations. PLoS ONE 6(2), e17047. doi:10.1371/journal.pone.0017047.
43. Zald, D.H., R.L. Cowan, P. Riccardi, R.M. Baldwin, M.S. Ansari, R. Li, E.S. Shelby, C.E. Smith, M. McHugo, & R.M. Kessler (2008). Midbrain Dopamine Receptor Availability Is Inversely Associated with Novelty-Seeking Traits in Humans. The Journal of Neuroscience, 31 December 2008, 28(53), 14372-14378; doi: 10.1523/ JNEUROSCI.2423-08.2008

 ISBN: 978-93-90214-19-8

Role of Multiple Tuned Liquid Mass Dampers in Tall Buildings

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Abstract: **High rise buildings with asymmetric plan configuration are highly vulnerable to seismic induced vibrations on account of large amount of base shear, large lateral displacement and twist of each story. The asymmetry in the building plan can't be compromised due to the architectural requirements and the buildings utilities. Many techniques are attempted to minimize the base shear, lateral displacement and the twist using methods such as base isolation techniques, tuned massed dampers and the liquid tuned mass dampers. However, though the attempts are found to be fruitful, they are expensive, unacceptable and sometimes not feasible. In this scenario the liquid tuned mass dampers are found more suitable and are viable. The liquid tuned mass dampers are modeled making use of the overhead water tanks in buildings, which are the integral part of the building structures. As a reason no extra investment is needed in developing the liquid tuned mass dampers. Many research works are carried out using liquid tuned mass dampers since the early twenty first century. These studies are in general carried out using a single liquid tuned mass damper for a given building. The method, even though found to be very encouraging for a rectangular building plans, not found satisfactory for other plan shapes. When the plan of the building is too large or non-symmetrical or non-rectangular, locating one liquid tuned mass damper in the plan becomes debatable. In such cases more than one liquid tune mass damper is needed to be provided to reduce the dynamic disturbances in the building. The effect of multiple liquid tuned mass dampers on the unsymmetrical buildings is to be studied in the present work. The study is carried-out on L-shape building, T-shape building and U-shape building of G+10 story in different seismic zones. The present work involves in modeling the structures using ETABS package. The structural analysis is to be carried using linear time history analysis. The multiple overhead water tanks serve the purpose of multiple liquid tuned mass dampers.**

Index Terms: **Multiple Liquid tuned mass dampers, Base shear, Lateral displacement, Asymmetric plan, water tank.**

I. INTRODUCTION

For growing population, the only solution for accommodation remains vertical expansion, when horizontal expansion is limited. High structures pose greater challenges to structural engineer in form of stability and safety. With high density tall buildings are vulnerable to lateral forces like wind forces and earthquakes. Lateral displacements at foundation level prove much risk to a buildings stability and pose threat to lives. Hence it becomes a necessary to increase stiffness and improve the structural configuration of buildings to overcome these hurdles.

The introduction of Tuned Mass Damper proved to be highly effective in reduction of base shear and amplitude of vibrations of structures subjected to lateral forces and displacements. Amongst the Tuned Mass Dampers, the usage of Liquid Tuned Mass Dampers is more encouraged. Since the overhead water tanks are integral part of a structure, they can serve as Tuned Liquid Mass Dampers and are considered as a very cost-effective solution in seismic design.

In the present study, the mass of water in the tank plus the mass of the water tank is considered to constitute the total mass of the Tuned Mass Damper. The stiffness of the columns of the water tank would serve as the stiffness of the Tuned Mass Damper. The structural damping due to the concrete structure constitute the damping of the Tuned Mass Damper. By suitably altering the mass of liquid in the water tank, the sizes of the water tank and the number and size of the column elements supporting the water tank, the mass, the damping and the stiffness of the Tuned Liquid Damper is tuned.

A. *Objective of the study*

In the present work, the studies are extended to investigate the contribution of multiple liquid tuned mass dampers. Having already appreciated the need to introduce multiple liquid tuned mass dampers, the present work is taken-up with following objectives:

1. To suitably choose the size of the water tank, mass of the water tank with water as a ratio of mass of the

ISBN: 978-93-90214-19-8

structure and the number and sizes of the columns supporting the water tank to arrive at an optional configuration of the Liquid Tuned Mass Damper.

2. Proposing either single or multiple numbers of Liquid Tuned Mass Dampers together with their locations and all parameters.
3. The overall arrangement should result in the lowest possible base shear and lateral displacement, yet economical in the event of seismic disturbance to the building.

B. Procedure Adopted

In this current project, ETABS package has been utilized for Linear Time History analysis on a RCC building subjected to seismic load. A G+10 story building, with and without Liquid Tuned Mass Dampers, located in zone–III and zone–IV of seismic disturbances having plan configuration of L–shaped, T-shaped, U–shaped and Rectangular buildings are considered. The studies are repeated by varying the water level in tanks as empty, one-third full, two-third full and full water tank conditions and the locations of the water tanks are altered to result in optimum values of seismic disturbances.

II. LITERATURE REVIEW

A Shruthi and Dr. N. Murali Krishna had proposed a suitable method to choose the size of the water tank and mass of the water tank with water to arrive at an optimal configuration of the Liquid Tuned Mass Damper. The Tuned Liquid Mass Damper (TLMD) is modeled with the help of overhead water tanks which form an integral part of the building. The structural effectiveness of building with and without TLMD is presented by carrying-out the structural analysis using both Response Spectrum Method and Linear Time History Analysis. The performance of the tuned liquid mass dampers is demonstrated by comparing the values of Maximum Story Deflection and the magnitudes of Base shear of the building for different tank capacities. The study was carried on an RC building with asymmetric plan configuration, located in a highly seismic active region using ETABS.[1]

Mudabbir Imran and Dr. B. K. Raghu Prasad had examined the effectiveness of both single and multiple tuned mass dampers (TMDs) when subjected to various earthquake ground accelerations using ETABS. It was seen that MTMD with Non-uniform mass ratio was more efficient than MTMD with uniform mass ratio but it cannot be economical. [2]

Lucchini et al proposed a method for designing a TMD system for the seismic protection of a multi-storey buildings. It was found that with the increase of the total mass of the TMD system, its performance tends to improve, the building response reduces and becomes less sensitive to the uncertain parameter variations. Uncertainty in the properties of the ground excitation reduces robustness of the TMD system by increasing the variation of its performance. With the increase of the uncertainty level, it has been observed that period and damping of the TMD units increases. [3]

S.M. Zahrai and A. Ghannadi-Asl had discussed the effectiveness of Tuned Mass Dampers (TMDs) to control the structures under earthquake excitations using tuned mass dampers for buildings with different number of stories and heights. The results of time-history analysis were compared with those of a response spectrum analysis for the structures with and without TMD in order to judge its effectiveness. It was observed that TMD is effective in reducing maximum displacement in MRF buildings of Tabas earthquake and El Centro earthquake. [4]

Ashish A. Mohite et al had carried out the analysis of the seismic behaviour of different storeys of a building with tuned mass damper and without tuned mass damper by using ETABS. It was found that the TMDs can be successfully used to control vibration of the structure. For the regular building frame, TMD was found to effectively reduce top storey displacement. The reduction was found to be decreasing in a descending order from bottom storeys to top storey. With these results it was concluded that the TMD should be placed at top floor for best control. [5]

Saurabh Chalke and Prof P.V. Muley had discussed the vibration control of framed structure using tuned mass damper by using ETABS 2015, by analyzing a G+51 storey structure without damper and with tuned mass damper and compared the displacement and drift values under the dynamic condition. It was concluded that the values of displacement and drift were found to be more on structure when acted upon by dynamic conditions without damper. By assigning Tuned Mass Damper to the structure, it was found to be more stable as the values of displacement and drift were reduced and the acceleration also been reduced significantly using tuned mass damper. [6]

Rajashekhar S. Talikoti et al had studied the effectiveness of TMD in controlling the vibrations of structure. A building structure was modelled with and without TMD and Response spectrum analysis was carried-out. From the study it was found that TMD was more effective when it is attached at the top floor of building and the presence of TMD resulted in gradual decrement of the

ISBN: 978-93-90214-19-8

displacement, the storey drift and the fundamental period of the structure. [7]

Manjusha M had carried out the analytical investigation to study the feasibility of implementing water tank as a passive Tuned Mass Damper (TMD) using ETABS 2015. Multi-storey concrete building structure was taken for the study and a water tank was placed on the roof. The mass and frequency of both were tuned to the optimized values. The behavior of the tank under full and empty tank condition subjected to earthquake data was studied. It was concluded that TMD had effectively reduced the overall behavior of the structure resulting in economic and safe design and can successfully be used to control the response of the structure. [8]

M.J Tait et al investigated the performance of unidirectional and bidirectional tuned liquid dampers (TLDs) under random excitation. A series of experiments were carried-out on scale model structure-tuned liquid damper systems to evaluate their performance. The results are compared with those of a well-known tuned mass damper. This study has resulted in the development of performance charts for a tuned liquid damper. These charts allowed the efficiency of a tuned liquid damper to be examined for a number of varying parameters, which included the excitation amplitude, water depth and building frequency. It was concluded that a TLD is efficient and robust to reduce dynamic structural motions that occur as a result of random excitation. [9]

Chidige Anil Kumar and E Arunakanthi analyzed the feasibility of implementing water tank as passive TMD and found the optimum level of water which would reduce peak response of the structure subjected to seismic forces using SAP2000 by considering a three and seven storey building designed for gravity and seismic using 1893:2002. Influence of TLD was found to be effective and the model study showed encouraging results for Bhuj earth quake data. It was found that the roof displacements, story drifts, time period and base shear have been reduced for 2/3 level of water tank model compared to other levels concluding 2/3rd level as the optimum level of water to be maintained for effective results. It was concluded by them that if the level of water in the tank is maintained between half full to two thirds full (having mass ratio 25%) there is a tendency to mitigate the vibrations of RC frame structures under seismic excitations. [10]

III. METHODOLOGY

The dynamic analysis of the building is carried out using Linear Time History method corresponding to seismic Zone-III and IV of seismic activities.
Modelling of structure using TLD is as follows

1. A three-dimensional model of G+10 story building structure is created using ETABS.
2. Creating and assigning Material properties.
3. Creating and assigning Section properties.
4. Linear Time history function is defined for the desired zones considered in the study.
5. Assigning the external and internal wall loads acting on the structure wherever necessary.
6. Assigning the floor finish load and live load acting on slab panels.
7. The building is modelled with one, two, three overhead water tanks, created at the desired location on the topmost floor of the existing building structure.
8. The water tanks with desired length, width and height are created and the beam, column and slab properties are assigned.
9. The next step is modelling a Tuned Liquid Damper which is attached to the water tank of the same building.
10. A TLD is modelled in ETABS using a combination of 'Linear link type' and a 'Point spring' attached in series.
11. From Define→Section properties→Link/support properties, add a new link property by selecting the 'Linear link type'. The directional properties U1, U2, and U3 are selected in which U3 type is fixed.
12. From Properties option→modify/show all→the stiffness and damping values for U1, U2 directions are entered.
13. Mass and weight of the TLD (the water) is entered, which is the load acting on the water tank or the weight of water present in the water tank. In this step, the water level is varied to effect the changes in the values of mass and weight of TLD and changes are affected in the stiffness and damping as well.
14. Define →Spring properties→Point springs→Add new spring, select the 'User specified/link properties option'.
15. From the 'single joint links at point' dialogue box, add the previously defined link property and the axial direction '+z' selected.
16. Links are drawn using 'draw link' option.
17. The links are connected to the columns in '+z' direction (upward), along which the water tank is standing.
18. The point spring which is defined earlier is assigned to the joints at the base of the water tank by using 'Draw springs' option.
19. The mass of the TLD is assigned towards the free end of the link by selecting the joints of water tank, where springs and links are connected.
20. From the command Assign→Joint loads, the load value is assigned in downward or '-z' direction. The total load acting on the water tank is divided equally on to the number of columns on which it is standing.

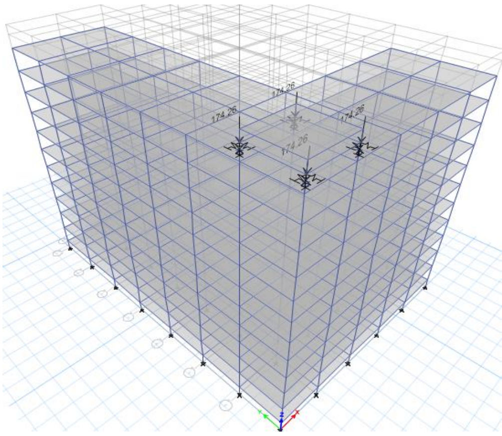

Figure 1. Plan with Joint loads in ETABS

The buildings considered for the study are ordinary moment resisting reinforced concrete space frames of G+10 and G+15 story high, both symmetric and asymmetric plan configurations. The analysis is carried-out on a rectangular shaped building and three different asymmetric shaped buildings of plan shapes L, T and U using ETABS software. The following are the three cases models used in the study

Case I: G+10 Story Buildings with Single Water Tank
Case-II: G+10 Story Buildings with Double Water Tank
Case-III: G+10 Story Buildings with Triple Water Tank

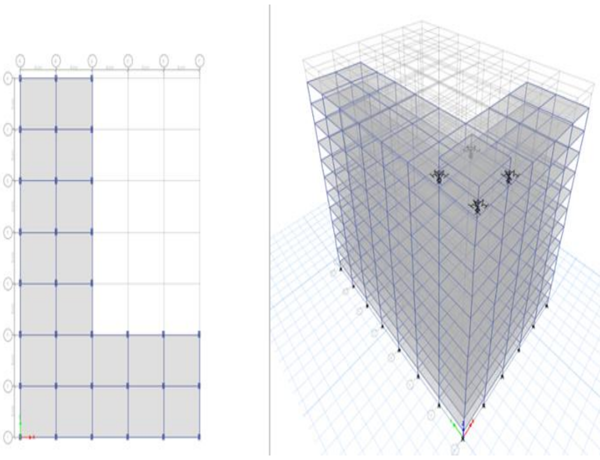

Figure 2. Plan and Isometric view of G+10 building with single water tank

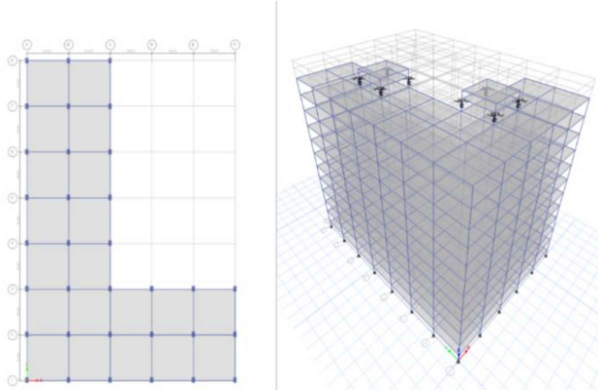

Figure 3. Plan and Isometric view of G+10 building with double water tank

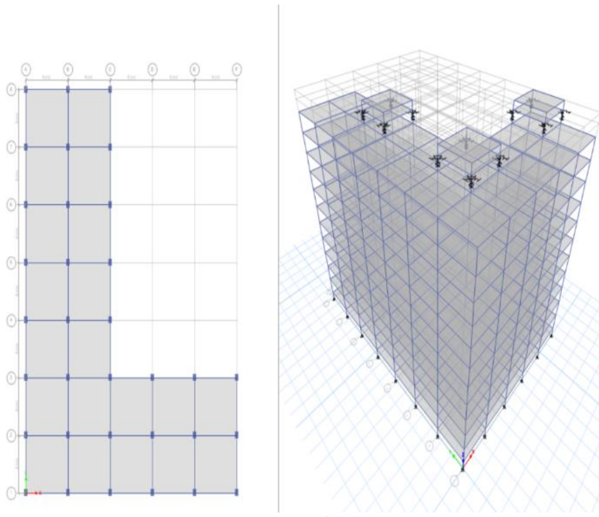

Figure 4. Plan and Isometric view of G+10 building with triple water tank

IV. Specimen Calculations

The Preliminary data for the Analysis of the frame in ETABS is assumed as per practical considerations which

is presented below.

1. Type of structure - Moment Resisting Frame
2. Materials - M30, Fe-500
3. Size of Beams - 300x450 mm
4. Size of Columns - 450x750 mm
5. Depth of slab - 150 mm
6. External Wall load - 11.14KN/m,
7. Internal Wall load - 5.57KN/m
8. Seismic zone factor - 0.16 & 0.24

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9. Response Reduction Factor - 5

A. Calculations of Water Tank for Model-1

Total mass of the structure = 70209.18KN

Water required for single person= 135 liters

No. of persons in each flat =5

No. of flats in the building =25

Total no of persons =125

Water required =16875Litres

Water tank height = 0.75 m

Volume of tank = LxBxH

Area of tank (LxB) = 22.5 m^2

L = 6 m

B = 6 m

H = 0.75 m

Total dead load = 530.82KN

Live Load (Water Required) = 165.48 KN

Total water tank load = 697.05KN

B. Calculations of the Tuned Liquid Damper for Model-1

Mass ratio (γ) = $\dfrac{\text{Mass of the water tank}}{\text{Mass of the structure}}$

Natural frequency (ω_n) = 1.874rad/sec

Time period (Tn) = 3.351 sec

Tuning ratio (f_{opt}) = $\dfrac{1}{1+\gamma}$

Optimum damping ratio (ξ_{dopt}) = $\sqrt{\dfrac{3\gamma}{8(1+\gamma)}}$

Optimum stiffness $K_{opt} = \gamma k f_{opt}^2$

Optimum Damping $C_{opt} = 2\omega m \xi_{dopt}\gamma$

TABLE 1

CALCULATIONS OF TLMD PARAMETERS FOR VARYING WATER LEVEL IN THE TANK

	Empty Water tank	One-third level Water	Two-third level water	Full water tank
Mass ratio	0	0.003	0.006	0.0099
Tuning ratio	1	0.996	0.993	0.9901
Optimum damping ratio	0	0.035	0.049	0.0613
Optimum stiffness (KN/m)	0	82.72	164.37	244.94
Optimum Damping (KN-s/m)	0	30.74	87.09	160.26

TABLE 2

DATA REQUIRED TO MODEL A TLD IN ETABS

	Empty Water tank	One-third level Water	Two-third level Water	Full water tank
Mass of the damper (Kg)	0	23693.06	47386.13	71079.19
Weight of the damper (KN)	0	232.35	464.70	697.05
Stiffness in translation X&Y directions (KN/m)	0	82.728	164.371	244.944
Stiffness in translation Z direction (KN/m)	3080.93	3080.93	3080.93	3080.93
Damping (U1 and U2) (KN-s/m)	0	30.742	87.09	160.26

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V. RESULTS AND DISCUSSIONS

After analyzing the RCC building of ten-story high using Linear Time History Analysis method with and without TLD’s, the results obtained in respect of base shear and maximum story displacement in two orthogonal directions are tabulated in Tables. The studies are carried-out with water tank empty, one-third full, two-third full and full condition. The information furnished in the tables clearly illustrates the utility of adopting the TLD approach. The critical list of observations made for ten story buildings located in zone-3 seismic intensity are shown in Tables below.

TABLE 3

TIME HISTORY BASE SHEAR IN X DIRECTION FOR BUILDING WITH SINGLE WATER TANK

	Empty Water tank	One – third level Water	Two-third level Water	Full water tank
Without TLD	682.29 KN	683.44 KN	684.03 KN	684.83 KN
With TLD	682.29 KN	720.53 KN	748.47 KN	763.96 KN

TABLE 4

TIME HISTORY BASE SHEAR IN Y DIRECTION FOR BUILDING WITH SINGLE WATER TANK

	Empty Water tank	One-third level Water	Two-third level Water	Full water tank
Without TLD	728.98 KN	727.24 KN	725.79 KN	724.92 KN
With TLD	728.98 KN	349.26 KN	349.77 KN	350.27 KN

TABLE 5

MAX STORY DISPLACEMENT FOR THA LOAD CASE IN X DIRECTION FOR BUILDING WITH SINGLE WATER TANK

	Empty Water tank	One – third level Water	Two-third level Water	Full water tank
Without TLD	86.88 mm	86.93 mm	86.98 mm	87.03 mm
With TLD	86.88 mm	80.85 mm	71.92 mm	64.87 mm

TABLE 6

MAX STORY DISPLACEMENT FOR THA LOAD CASE IN Y DIRECTION FOR BUILDING WITH SINGLE WATER TANK

	Empty Water tank	One – third level Water	Two-third level Water	Full water tank
Without TLD	84.84 mm	84.88 mm	84.91 mm	84.95 mm
With TLD	84.84 mm	15.55 mm	15.46 mm	15.24 mm

1. For building with L-Shaped plan of ten-story high, with one tank and no damper, the magnitude of maximum base shear and displacement are found to reduce as the water tank is filled with more water.
2. The same building as above, with one tank modelled as the liquid damper, the base shear is found to increase along X-direction and decrease along Y direction. However, the overall displacements are found to reduce as the water tank is filled with more water.
3. As a summary, for L-Shaped buildings of ten-story high with one water tank, when dampers are introduced, the base shear has slightly increased when tanks carry more water as compared to the tank without dampers in one direction. But the maximum displacement reduced by 43% when dampers are introduced.

TABLE 7

TIME HISTORY BASE SHEAR IN X DIRECTION FOR BUILDING WITH DOUBLE WATER TANK

	Empty Water tank	One – third level Water	Two-third level Water	Full water tank
Without TLD	688.84 KN	688.59 KN	688.66 KN	688.88 KN
With TLD	688.84 KN	757.89 KN	794.36 KN	820.03 KN

TABLE 8

TIME HISTORY BASE SHEAR IN Y DIRECTION FOR BUILDING WITH DOUBLE WATER TANK

	Empty Water tank	One – third level Water	Two-third level Water	Full water tank
Without TLD	787.96 KN	776.07 KN	761.43 KN	749.37 KN

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With TLD	787.96 KN	345.76 KN	345.87 KN	352.22 KN

TABLE 9

MAX STORY DISPLACEMENT FOR THA LOAD CASE IN X DIRECTION FOR BUILDING WITH DOUBLE WATER TANK

	Empty Water tank	One – third level Water	Two-third level Water	Full water tank
Without TLD	86.80 mm	86.84 mm	86.88 mm	86.91 mm
With TLD	86.80 mm	68.93 mm	57.14 mm	48.74 mm

TABLE 10

MAX STORY DISPLACEMENT FOR THA LOAD CASE IN Y DIRECTION FOR BUILDING WITH DOUBLE WATER TANK

	Empty Water tank	One – third level Water	Two-third level Water	Full water tank
Without TLD	86.14 mm	86.15 mm	86.21 mm	86.28 mm
With TLD	86.14 mm	13.01 mm	12.93 mm	12.88 mm

4. For L-Shaped building of ten-story high with two water tanks, the magnitude of maximum base shear has reduced as more water is added to the tank, but the maximum displacement remained unchanged when no dampers are introduced.

5. L-Shaped building of ten story high with two water tanks the base shear is found to increase along X-direction and decrease along Y direction. However, the overall displacements are found to reduce as the water tank is filled with more water.

6. L-Shaped building of ten-story high with TWO water tanks, when dampers are introduced the base shear has slightly increased when tanks are filled as compare to the tanks without dampers, but the maximum displacement was 58% less when dampers are introduced.

TABLE 11

TIME HISTORY BASE SHEAR IN X DIRECTION FOR BUILDING WITH TRIPLE WATER TANK

	Empty Water tank	One –third level Water	Two-third level Water	Full water tank
Without TLD	689.71 KN	690.57 KN	691.78 KN	693.00 KN
With TLD	689.71 KN	784.08 KN	825.56 KN	862.69 KN

TABLE 12

TIME HISTORY BASE SHEAR IN Y DIRECTION FOR BUILDING WITH TRIPLE WATER TANK

	Empty Water tank	One – third level Water	Two-third level Water	Full water tank
Without TLD	706.61 KN	704.86 KN	704.51 KN	703.33 KN
With TLD	706.61 KN	338.61 KN	346.16 KN	349.10 KN

TABLE 13

MAX STORY DISPLACEMENT FOR THA LOAD CASE IN X DIRECTION FOR BUILDING WITH TRIPLE WATER TANK

	Empty Water tank	One – third level Water	Two-third level Water	Full water tank
Without TLD	87.41 mm	87.56 mm	87.69 mm	87.84 mm
With TLD	87.41 mm	63.01 mm	50.57 mm	42.03 mm

TABLE 14

MAX STORY DISPLACEMENT FOR THA LOAD CASE IN Y DIRECTION FOR BUILDING WITH TRIPLE WATER TANK

	Empty Water tank	One– third level Water	Two-third Level Water	Full water tank
Without TLD	86.74 mm	86.87 mm	86.98 mm	87.09 mm
With TLD	86.74 mm	12.45 mm	12.43 mm	12.42 mm

7. For L-Shaped building of ten story high when THREE water tanks are introduced the magnitude of maximum base shear has reduced as tank is filled with water but the maximum displacement remains unchanged when no dampers are introduced.

8. L-Shaped building of ten story high when THREE water tanks, the base shear is found to increase along X-direction and decrease along Y direction. However, the

overall displacements are found to reduce as the water tank is filled with more water.

9. L-Shaped building of ten-story high with THREE water tanks, when dampers are introduced the base shear has slightly increased when tanks are filled as compare to the tanks without dampers, but the maximum displacement was 63% less when dampers are introduced.

VI. Conclusions

In the present work, the dynamic analysis using ETABS package is performed on G+10 story RCC buildings of different plan shapes in zone-3 and zone-4, with and without tuned liquid dampers. The results pertaining to base shear and maximum floor displacements are tabulated.

Based on the studies carried out on different shapes of buildings in different seismic zones, the following conclusions are made:

1. Introduction TLD modelling of water tanks have invariably reduced the magnitudes of base shear and maximum lateral displacements to an extent of twenty percent.
2. Increasing water levels in the tanks, with either single or multiple TLD’s have resulted in the marginal increase in base shear in one direction but found to be reduced along weak axis (Y direction). The maximum lateral displacements for RCC buildings with L shaped plan were found to be substantially reduced.
3. A similar behavior is noticed for buildings with rectangular, T shaped and U-shaped plan as well.
4. Even though the magnitudes of base shear and maximum lateral displacement increase are higher for zone-4 in relation to zone-3, the magnitudes of base shear and maximum lateral displacements have exhibited a similar trend.
5. The structural design of high rised RCC buildings with multiple water tanks is most economical when the water tanks are modelled as TLDs. For design purpose, the maximum values of base shear and maximum lateral displacements shall be considered based on the quantum of water in tanks.
6. Even though, the sizing of water tank is decided based on the water requirements of a building, they are divided into multiple numbers to cause minimum dynamic disturbance to the building, in the event of seismic activity.

References

[1] A Shruthi and Dr. N. Murali Krishna “Role of Liquid Tuned Mass Dampers in Improving Torsional Competence of Asymmetric Buildings”, CVR Journal of Science and Technology. (2019)

[2] Mudabbir Imran, Dr. B. K. Raghu prasad “Seismic Response of Tall Structures Using Tuned Mass Dampers”, IJREAS (2017)

[3] A. Lucchini, R. Greco, G. C. Marano and G. Monti “Robust Design of Tuned Mass Damper Systems for Seismic Protection of Multi-storey Buildings”, ASCE (2014)

[4] Emiliano Matta, “Effectiveness of Tuned Mass Dampers against Ground Motion Pulses”, ASCE (2013)

[5] S.M.Zahrai, A. Ghannadi-Asl “Seismic Performance of TMDs in Improving the Response of MRF Buildings”, Scientia Iranica (2008)

[6] Ashish A. Mohite, G.R. Patil “Earthquake Analysis of Tall Building with Tuned Mass Damper”, IOSR (2015)

[7] Ahmed Abdelraheem Farghaly, Mahmoud Salem Ahmed “Optimum Design of TMD System for Tall Buildings”, International Scholarly Research Network (2012)

[8] Saurabh Chalke, P.V. Muley “Vibration Control of Framed Structure Using Tuned Mass Damper” International Journal of Engineering Development and Research (2017)

[9] Khemraj S. Deore, Dr. Rajashekhar S. Talikoti, Kanhaiya K. Tolani “Vibration Analysis of Structure using Tuned Mass Damper”, International Research Journal of Engineering and Technology (2017)

[10] Manjusha M, Dr.Vra Saathappan “Analytical Investigation of Water Tank as Tuned Mass Damper Using Etabs”, International Research Journal of Engineering and Technology (2017)

[11] M. J. Tait, N. Isyumov, A. El Damatty “Performance of Tuned Liquid Dampers”, ASCE 2008)

[12] Dorothy Reed, Jinkyu Yu, z Harry Yeh, Sigurdur Gardarsson “Investigation of Tuned Liquid Dampers under Large Amplitude Excitation”, ASCE (1998)

[13] Chidige Anil Kumar, E Arunakanthi “A Seismic Study on Effect of Water Tank modelled as TMD”, International Journal of Innovative Research in Science, Engineering and Technology (2017)

[14] Dargush and Soong “Passive energy dissipation system for structural design and retrofit”

[15] Fahim Sadek, Bijan Mohraz, Andrew W. Taylor and Riley M. Chung “A Method of Estimating the Parameters of Tuned Mass Dampers for Seismic Applications” (1997)

[16] Den Hartog “A book on Mechanical Vibrations”

Green Building Rating Tools: A Literature Review

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Abstract*— Urbanization has increased the demand for buildings and other infrastructure especially in metropolitan areas. To accommodate this need, there has been an increase in the built environment. The Building sector is responsible for half of the world's greenhouse gas emission, causing adverse impacts on climate and the natural environment. The adoption of green building instead of conventional building minimizes the harmful effects on climate and natural environment by reducing carbon footprint, using less energy and use of sustainable building materials. To ensure the success of green buildings, assessment of the buildings is done using Green building rating systems governed by a set of criteria. This paper focuses on the importance of adopting green building instead of conventional building. It presents vital environmental technological techniques, modern trends in Green Building and applications of green building design for green buildings in different countries around the world. The benefit of life cycle analysis as an innovative ideology in Green Building rating system is shown. In addition, the paper showcases the rating systems used in India namely, Green Rating for Integrated Habitat Assessment (GRIHA), Indian Green Building Council (IGBC) and Leadership in Energy and Environmental Design (LEED) India.

Index Terms— ***Assessment Tools, Green Building, Rating System, Sustainable building.***

I. INTRODUCTION

Extensive growth of population in recent decades has resulted in urban expansion majorly in metropolitan regions. This has led to the significant increase in housing demand in this pervasive urbanization. Such a phenomenon brings a vast range of challenges associated with environmental, social and economic aspects. Grappling with inadequate affordable housing facilities has affected the socio-economic and settlement morphology of the country.

The need to preserve our environment prompted the implementation of the green building concept as part of sustainable living. Green buildings being structures that have fewer adverse effects on the climate and the environment due to their design, construction, and operation. Green buildings help to reduce the energy consumed by the building without compromising the comfort levels. The implementation of green building rating tools is essential to the performance of the buildings. These tools have green rating measures that need to be met, consequently the total score is attained after appropriate weighting. [1]

II. IMPACT OF BUILDING CONSTRUCTION ON THE ENVIRONMENT

The current scenario of climate change has boosted the need for sustainable building. As per statistics of the International Energy Agency (IEA), Buildings contribute to more than one-third of global energy consumption and are responsible for 50% of the global Green House Gas (GHG) emission [2]. Extreme GHG emission is known as a major factor of not only global warming but also climate change [3]. India is among the top 10 largest contributors to GHG emission in the world. The construction sector in India is responsible for 22% of the total annual emission of CO_2 [4]. Some construction materials such as cement which is a key component of construction, are major sources of CO_2 emissions, the main GHG in several countries [3].

Toxic construction chemicals (admixtures), debris, and dirt contribute to pollution through surface runoff which poisons large water bodies. It is also important to note that the processing activities for such construction chemicals and materials release greenhouse gases such as water vapor, methane, carbon dioxide, nitrous oxide, and ozone which relatively reduces the quality of surrounding air [5].

Similarly, construction waste poses a threat to the environment by increasing pollution, deteriorating land, and depleting resources. Consequently, as per an investigation in India, the total waste from the construction industry could reach 12-14 metric tons per year [6].

Furthermore, the surge in the need for material resources has led to land exploitation. About 40% of material resources needed for construction are obtained from nature [7]. This has to irreversible environmental impact because of the broad spectrum of on-site, off-site, and operational activities. Prominent damage is created due to change in the surface of the land due to structural development leading to silt bearing runoff and sediment pollution.

III. Green Building

A. Definition

Green building means the structure and the use of processes that are environmentally dependable without exhausting resources throughout a building's life cycle phases: from planning to design, construction, operation, maintenance, renovation, and demolition. This requires that the contractor, architects, engineers, and the client work together throughout the project.

B. Benefits of Green Building

The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. In doing so, the three-dimensional sustainability namely planet, people, and profit across the entire supply chain need to be considered.

Green structures can prompt: (1) Minimised working expenses by expanding cost-effectiveness and utilizing less energy and water, (2) Improved health of the public and tenant because of improved indoor air quality, and (3) Decreased negative natural effects for example the warming impact.

The main purpose of sustainability in green buildings is to reduce the negative effects of housing on life and the environment during the life cycle. These are often referred to as green constructions that provide the maximum benefit and ease of use. Some of the environmental problems that arise with unplanned urbanization are the risk of water pollution, a decrease in groundwater reserves, and the threat of extinction of wetlands [8].

C. Difference between Green Building and Conventional Building

The world is now adopting green buildings over conventional buildings to reduce the amount of energy required for operating buildings. Unlike conventional buildings, green buildings use an average of 30% less energy, reduce CO_2 emissions by 35%, reduce waste output by 70%, and water by 40%. Green buildings save on cost, reduce carbon footprint better than conventional buildings. Also, the materials used in green building can be recycled material and help decrease pollution, like wool and wood fiber is used for insulation; straw bale, stones, and timber frame is used for structural work; bamboo, corkwood, hardwood, and stone are used for flooring while as in conventional building, foam board and thermal wrap are used for insulation, bricks, concrete and metal are used in the structural work, concrete, wood laminate, and tile are used in the flooring work [9].

IV. Green Building Rating Systems

Green building rating systems are used to evaluate the level to which buildings meet green requirements or criteria. The Rating system acts as a reward and enticement for companies and organizations to participate in green building. Green Building rating system focuses on green features under the following categories: (a) Sustainable architecture and design, (b) Selection of site, (c) Water conservation, (d) Energy efficiency, (e) Building materials and resources, (f) Indoor environmental quality, (g) Innovation and development [10].

Each criterion has pre-allocated points or performance benchmarks and goals that the building must meet. Rating systems differ in the type of building (homes, commercial buildings, or even whole neighbourhoods) they are applied to. Examples of green building rating tools used around the world are Leadership in Energy & Environment Design (LEED) in the US, Building Research Establishment Environmental Assessment Method (BREEAM) in the UK, German Sustainable Building Council (DGNB) in Germany, Valoración de Eficiencia de Referencia de Edificios (VERDE) in Spain and Haute Qualité Environnementale (HQE) in France. In India, the rating tools used are LEED India, Green Rating for Integrated Habitat Assessment (GRIHA), and Indian Green Building Council (IGBC).

LEED was developed by United States Green Building Council (USGBC) to promote sustainability using Green Building. The benchmarks for the rating system were developed in 2000 and are available for existing, and new buildings. CII created IGBC in 2001. IGBC has several rating systems available, for example, IGBC Green Homes, IGBC Green Existing Buildings and IGBC Green Schools, just to mention a few. GRIHA was developed by The Energy and Resources Institute (TERI) in 2007 and is the national rating system for Indian green buildings. The Ministry of New and Renewable Energy also adopted the rating system [11].

Table I. Rating awarded as per Rating System [12], [13], [14]

LEED-India	
Rating	Points
Certified	40 – 49
Silver	50 – 59
Gold	60 – 79
Platinum	80 and more
GRIHA	
Rating	Points
Five star	91 – 100
Four star	81 – 90
Three star	71 – 80
Two star	61 – 70
One star	50 – 60
IGBC	

ISBN: 978-93-90214-19-8

Rating	Points
Certified	51 – 60
Silver	61 – 70
Gold	71 – 80
Platinum	81 – 100

V. Literature review

This section presents some existing literature in the field of green building. It starts with the discussion on the building sector then the benefits of green buildings, features of green buildings, innovative techniques in green building, and finally the assessment of green building using green building rating tools.

The building sector is one of the highest growing energy consumers and in the future, it is to hold the title due to the rapidly growing population [15]. Population growth and housing demand have forced policymakers to compromise on the environmentally friendly aspects of the buildings from the last two decades [16].

Green building provides the solution for increasing concern about environmental problems, energy, and resource consumption. From this point of view, it would be appropriate to start sustainability research by studying the overall performances of buildings using environmental aspects, the places where human beings perform their vital activities the most [8]. The implementation of green building practises will achieve the three Social, Environmental and Economical (SE2) benefits [10]. Green buildings can reduce the unwanted use of assets by enhancing the use of productivity of assets by implementing sustainable power sources. The principle of sustainability can be used to enhance energy efficiency in buildings. The following are the ways of ensuring the effectiveness of green buildings and reducing the use of energy: reducing the demand for energy, improved energy efficiency, and use of passive design techniques [17].

Smart features and the study of vitality sparing as part of building research scrutinize application policy of sun-oriented vitality, geothermal vitality, and wind vitality in building vitality sparing examination [18]. Another feature is the use of rainwater to minimise the harmful effects of urban life on the environment. Among other water sources, rainwater, collected using rain harvesting systems has a lower cost and poses a minor risk to human health [8]. Another common feature is "4R"- Reuse, Recycle, Reduce and Renewable. It facilitates the implementation of sustainable power sources in buildings **Error! Reference source not found.**. Some ideas utilized in green building are solar energy, green roofs, recycling, use of sustainable materials and methods.

To ensure effective implementation of green building, innovative techniques can be applied. Building Information Modelling (BIM) is used in the green building design stage but lately, the industry is realising its use in construction, facility and management stages. BIM has many applications, for example, it can be used in data exchange and integration, provides visuals of analysis of building performance and increases communication and partnership of stakeholders throughout the lifecycle of green buildings. The use of the "Green BIM Triangle" provides a suitable approach in understanding green BIM. The following are the main BIM functions for green analysis: energy performance analysis, natural ventilation system analysis, solar radiation and lighting analysis, water usage analysis, acoustics analysis and thermal comfort analysis. Examples of BIM software that are commonly used are Green Building Studio (BGS), Revit, ODEON Room Acoustics software and Integrated Environment Solutions Virtual Environment [19].

A sustainable built environment is achieved once all the environmental, social and economic needs are considered throughout the process of implementation. It is important to ensure that sustainable construction standards are introduced to architects and developers so that they can be implemented during the whole construction cycle. The following are the key factors for sustainable construction: reducing the impact on the environment, decrease in the use of resources, increase utility and make use of economic considerations. The sustainable energy performance of green buildings includes low energy buildings (LEB), ultra-low energy buildings (ULEB) and zero energy buildings (ZEB) [17].

Multi-criteria decision analysis (MCDA) and multi-criteria decision making (MCDM) have been utilized to solve many problems in the world. MCDM and fuzzy logic set theory can be used in the development assessment tools for green buildings performance. A great green building rating system should be able to include main indicators that will signify the attributes of the building and balance its performance [10].

Certification through any rating system verifies the green nature of the project and can be a valuable educational and marketing tool for owners and design and construction teams through the process of creating a more sustainable building [15]. In India, two certification processes, GRIHA and IGBC building assessment methods are available for assessing the greenness of commercial and residential buildings. These rating systems also must have scope to address the various climates of the country along with the socio-cultural and socio-economic norms [16].

Analysis done by harmonizing the concept of the triple pillar (environment, society, economy) formulates a sensitive basis for sustainable evolution, impact, toxicity, and development by screening with an integrated unified framework [20]. It is also important to analyse the actual status and effectiveness of rating tools which is significantly difficult by assessing behaviour and selection of users by its functionality [21].

ISBN: 978-93-90214-19-8

A study was conducted on a knowledge-based expert system as a rating tool to assess the performance level of green buildings based on assessment factors that are in green building rating systems. The knowledge-based expert system was developed with the use of the Analytic Hierarchy Process (AHP) and fuzzy logic. Fuzzy logic is a concept that developed from wanting to make a computer system have a human-like experience. AHP was used as a tool for group decision-making and to rank performance assessment criteria. To assess the final performance of green buildings the fuzzy interference system was applied. An important aspect to consider in the assessment of green buildings is the embodied energy during construction and demolition of the building [10].

Furthermore, a case study to find the connection between low Green House Gas (GHG) buildings and green buildings was conducted on two states of the art green buildings, Nanhaiyiku 3 in China and Pixel building in Australia. Both buildings received the highest green building ratings of their national rating systems and standards. It should be noted that green buildings do not signify low GHG buildings. This is because green building rating systems do not include GHG emission performance as a criterion.

The sources of emission during the lifecycle of the buildings were taken as embodied emissions (production and transportation of materials plus equipment, construction process), operation emissions, maintenance emissions and demolition emissions. The GHG emissions were calculated for a building life span of 50 years for both buildings. Over the 50-year life span, the embodied GHG emissions for Nanhaiyiku 3 were more than 41% of the total GHG emissions while the Pixel Building had a much higher percentage of embodied emissions. Pixel Building had operational GHG emission as negative and renewable energy in the building was high. The reason for the different GHG emission performances in these two buildings is the climate zones of the countries.

The two buildings have a high score in the green building rating system because of the green technologies used. But these technologies may not reduce total GHG emissions due to materials used, transportation, installation or operation of the technologies. These factors can lead to higher embodied emissions. It is essential to set up a GHG emission reduction goal all through the lifecycle of the building. The evaluation of GHG emission reduction on a single building should be carried out in terms of its life cycle wholly and there should be development and promotion of low GHG intensity energy and corresponding equipment [3].

CONCLUSION AND DISCUSSION

All countries must address climate change, create more sustainable communities and boost economic growth. Green buildings are a means to which all these can be achieved. The review of literature from articles, reviews, and conference papers revealed that India is not among the countries leading research into green building. There is a requirement for more green building professionals to raise public awareness on the subject and promote green projects. On another note, the conversion of conventional buildings to green buildings should be encouraged. This will not only help to reduce energy and cost savings but also improve many factors of the building such as indoor air quality, thermal comfortability and improved overall productivity and health of the building.

Some countries have developed their methods to define and certify green buildings depending upon their geographical location and resources. On a global scale, green building rating systems are largely voluntary and have helped raise awareness and promote green building designs. However, there needs to be more comparative analysis on green building rating systems in India. Also, for any green building, the assessment of performance throughout its lifecycle is important to find out if the building will attain success. The Green building should have low total lifecycle energy requirements and reduce adverse environmental impacts from the time of conception to the demolition of the building.

REFERENCES

[1] M. M. Kiran Joseph Victor Jose Mr Dinesh Kumar A N Mrs Sithara Mary Sunny, "A Review on various Green Building Rating Systems in India," *Int. J. Sci. Eng. Res.*, vol. 9, no. 5, 2018, [Online]. Available: http://www.ijser.org.

[2] "Tracking Buildings 2020," 2020. https://www.iea.org/reports/tracking-buildings-2020 (accessed Feb. 25, 2021).

[3] T. Wang, S. Seo, P. C. Liao, and D. Fang, "GHG emission reduction performance of state-of-the-art green buildings: Review of two case studies," *Renew. Sustain. Energy Rev.*, vol. 56, pp. 484–493, 2016, doi: 10.1016/j.rser.2015.11.037.

[4] "Reaffirming India's INDCs through GRIHA," Nov. 20, 2018. https://www.grihaindia.org/reaffirming-india.

[5] M. C. Bignozzi, "Sustainable cements for green buildings construction," *Procedia Eng.*, vol. 21, pp. 915–921, 2011, doi: 10.1016/j.proeng.2011.11.2094.

[6] C. S. Poon, "Management of construction and demolition waste," *Waste Manag.*, vol. 27, no. 2, pp. 159–160, 2007, doi: 10.1016/j.wasman.2006.10.012.

[7] T. Esin and I. Yüksek, "Sustainable resource utilisation in the production of building materials," *Int. J. Sustain. Build. Technol. Urban Dev.*, vol. 4, no. 2, pp. 141–145, 2013, doi: 10.1080/2093761X.2013.768186.

[8] E. Kucukkaya, A. Kelesoglu, H. Gunaydin, and G. A. Kilic, "Design of a passive rainwater harvesting system with green building approach," *Int. J. Sustain. Energy*, vol. 0, no. 0, pp. 1–13, 2020, doi: 10.1080/14786451.2020.1801681.

[9] K. Varma, M. Chaurasia, P. Shukla, and T. Ahmed, "Green Building Architecture: A Literature Review on Designing Techniques," *Int. J. Sci. Res. Publ.*, vol. 4, no. 1, pp. 2250–3153, 2014, [Online]. Available: www.ijsrp.org.

[10] M. Nilashi *et al.*, “A knowledge-based expert system for assessing the performance level of green buildings,” *Knowledge-Based Syst.*, vol. 86, no. November, pp. 194–209, 2015, doi: 10.1016/j.knosys.2015.06.009.
[11] I. Ap, V. Jose, and S. M. Sunny, “A Review on various Green Building Rating Systems in India,” vol. 9, no. 5, 2018.
[12] “LEED 2011 for India - NC,” no. March, 2014.
[13] IGBC, “IGBC Green Homes Rating System,” *Indian Green Build. Counc.*, vol. Version 2., p. 146, 2012, [Online]. Available: https://igbc.in/igbc/redirectHtml.htm?redVal=showResourcesnosign%0Awww.igbc.in.
[14] I. Green and B. Council, “Indian Green Building Council,” *J. Chem. Inf. Model.*, vol. 53, no. 9, pp. 1689–1699, 2013, doi: 10.1017/CBO9781107415324.004.
[15] K. Jain, “A Comparative Analysis of Green Building Rating Systems and Building Intelligence Evaluation Systems for Development of a Smart Building Rating System A Comparative Analysis of Green Building Rating Systems and Building Intelligence Evaluation Systems for,” no. July, pp. 0–20, 2019, doi: 10.13140/RG.2.2.33871.64167.
[16] M. K. Singh, S. Mahapatra, and S. K. Atreya, “Green building design: A step towards sustainable habitat,” *Renew. Energy Sustain. Dev.*, vol. 1, no. 1, pp. 257–268, 2010.
[17] A. Ghaffarianhoseini, N. D. Dahlan, U. Berardi, A. Ghaffarianhoseini, N. Makaremi, and M. Ghaffarianhoseini, “Sustainable energy performances of green buildings: A review of current theories, implementations and challenges,” *Renew. Sustain. Energy Rev.*, vol. 25, pp. 1–17, 2013, doi: 10.1016/j.rser.2013.01.010.
[18] Z. Yang, “Research on New Energy-saving and Efficient Utilization of Buildings Based on Renewable Energy,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 514, no. 4, 2020, doi: 10.1088/1755-1315/514/4/042016.
[19] Y. Lu, Z. Wu, R. Chang, and Y. Li, “Building Information Modeling (BIM) for green buildings: A critical review and future directions,” *Autom. Constr.*, vol. 83, no. February, pp. 134–148, 2017, doi: 10.1016/j.autcon.2017.08.024.
[20] B. Wen, N. Musa, C. C. Onn, S. Ramesh, L. Liang, and W. Wang, “Evolution of sustainability in global green building rating tools,” *J. Clean. Prod.*, vol. 259, p. 120912, 2020, doi: 10.1016/j.jclepro.2020.120912.
[21] J. Kallaos and R. A. Bohne, “Green residential building tools and efficiency metrics,” *J. Green Build.*, vol. 8, no. 3, pp. 125–139, 2013, doi: 10.3992/jgb.8.3.125.

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 ISBN: 978-93-90214-19-8

To study the seismic response of pile foundation by using PLAXIS 2D

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Abstract— Earthquake response of a structure on soil is influenced by material property and type of foundation. The research paper attempt to evaluate the influence of pile in term of acceleration and base shear force .Representative soil model is constructed with proper boundary conditions for dynamic analysis in PLAXIS 2D software. The soil model is then provided with structure to study the effect on piles. Two cases consisting of different structure with different foundation are studied on same soil conditions. Model 1 is 4 storey building with shallow foundation and model 2 is 4 storey building with raft pile. Geometric model and material model is constructed. The results of dynamic analysis show that the foundation type has small scale influence on seismic response of a structure. The extreme total acceleration of Model 1 is found out to be 0.193 m/s2 and for model 2 it is found to be 0.209 m/s2.

Index Terms— shear force, acceleration, plaxis 2D

I. INTRODUCTION

The earthquake anywhere in the world disturbs life and property, damages the economic development and prosperity and can even turn into calamity for victims of it. The ill effects of earthquake can be humongous and mostly unpredictable because of its sudden nature of evolution. So for sustainable development it is necessary to construct earthquake resilient structure. In that direction, it is important to study the impacts of earthquake on structural stability. Structural stability depends on various factors. The foundation is one such part of structure which plays vital role in response of structure to seismic forces. The present attempt of this paper is small contribution in study of seismic response of pile foundation in terms of acceleration and base shear and comparing the results with IS 1893:2002.

II. PROCEDURE

A. *Modeling stage*

The study is carried out on two models. First model is four storey building with raft foundation and second model is four storey building with raft pile foundation. Both the models were simulated by using PLAXIS 2D software and suitable material properties are assumed only for the purpose of study.

B. *Construction of geometry*

The modeling in PLAXIS begins with construction of geometry i.e specifying dimensions. The length of soil beneath the foundation considered is 100 meter and the depth is 20 meter. The building consist of 4 floor 3 meter each total height of building is 12m, width 6m and basement of 2m as shown in fig 1.

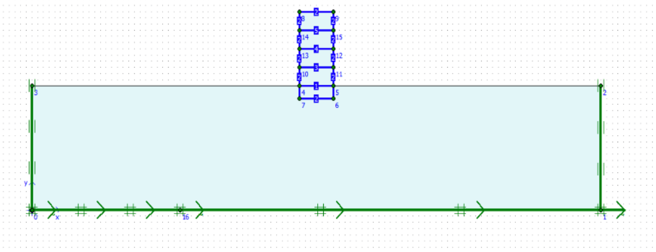

Fig 1.

C. *Application of boundary condition*

The earthquake boundary conditions are applied with application of standard fixities as per the general requirement of PLAXIS which ensures the definite soil condition, in order to get exact soil structure interaction. The displacement of 0.01 meter is applied in x direction and displacement in y direction is kept zero.

D. *Material properties*

The material model used here is MOHR-COULOMB
The material properties of soil model are mentioned in following table_
For model 1and model 2 the material properties are_

Parameter	Name	Value	unit
Material model	model	Mohr coulomb	-
Unit weight of	Yunsat Ysat	17 20	kN/m^3

soil			
Rayleigh damping	ALPHA,BETA	0.01	-
Poisson's ratio	V	0.3	-
Parameter	Name	Value	Unit
Material model	Model	Mohr coulomb	-
Normal stiffness	Eref :- V(nu):-	40000 0.300	kN/m^2
Shear Modulus	Gref :- Eoed :-	15380 53850	kN/m^2
Velocities	Vs Vp	94.17 176.20	
Strength	Cref Phi Psi	2.00 30.00 0.00	kN/m2 Degree Degree

The material property of plate which is used to simulate the building elements floor, wall, slab are as fallows_

Parameter	Name	Value	unit
Material type	Elastic	-	-
Normal stiffness	EA	5000000	kN/m^2
Flexural rigidity	EI	9000	kN/m^3
weight	W	3	kN/m/m
Depth	d	0.147	m
Rayleigh damping	ALPHA,BETA	0.01	-
Poisson's ratio	V	0.000	-

Material properties of plate used to simulate pile in model 2 are as follows_

Parameter	Name	Value	unit
Material type	Elastic	-	-
Normal stiffness	EA	50000	kN/m^2
Flexural rigidity	EI	3000	kN/m^3
weight	w	20	kN/m/m
Depth	d	0.85	m
Rayleigh damping	ALPHA,BETA	0.01	-
Poisson's ratio	V	0.000	- m/s^2

The material properties considered here are based on the assumption that the similar structure under natural condition would have what characteristics and the structure with similar characteristics is attempted to simulate in PLAXIS 2D and the material properties are assumed only for the purpose of the study. Since the main focus of this paper is on analyzing impact of earthquake load on foundation type.

III. Calculation

In calculation program dynamic analysis under total multiplier load is carried out. Here total multiplier load is applied in the form of SMC data file which consist of accelerogram of earthquake motion. This accelerogram is used to simulate seismic loading and dynamic analysis is performed on the models. The output for acceleration and shear force is analyzed at various locations to establish the relation between them. The acceleration is mainly compared at the top, basement and bottom node of the geometry. The position of the nodes are (53.00, 32.00), (53.00, 18.00) and (53.00, 0.00) respectively. The acceleration verses time curve for model 2 is as fallows_

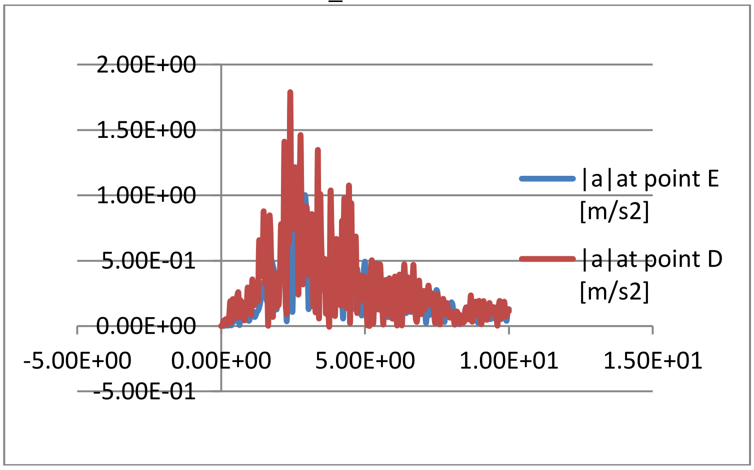

Fig 2: accelerogram for model 2 i.e raft pile foundation

In the above curve it is observed that the there is decrease in acceleration with increase in depth of the foundation. Point D (53, 18) is located at the basement or the top of the foundation slab. The acceleration produce at this point is 1.77m/s2 and the acceleration produce at point E (53, 0.66) at bottom of soil strata is 1.25m/s2. Similar procedure is fallowed to calculate the acceleration in model 1 also; the curve obtained is as fallows_

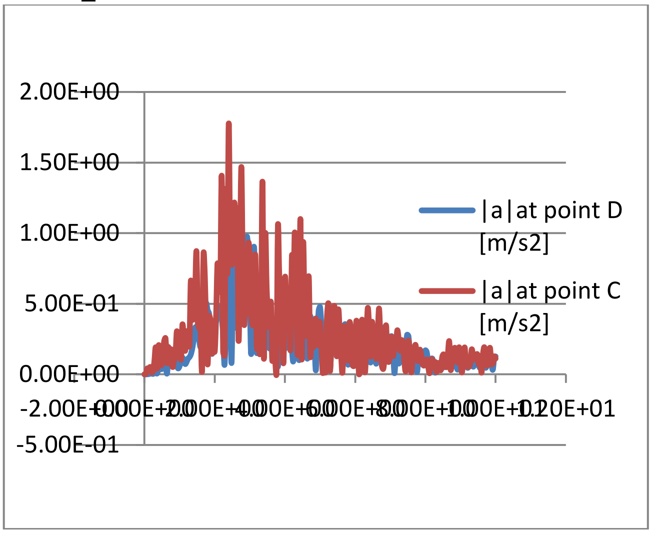

Fig 3: accelerogram for model 1 i.e raft foundation

In the above figure point C is located at basement and point D is located at bottom of the soil strata keeping the same position of nodes in both models. The amount of acceleration is analyzed for similar points as in model 2 and it is found that there is no significant difference in the acceleration for both the models. The amount of acceleration produced at point C is 1.77 m/s2 and at point D is 1.205 m/s2.

The extreme total acceleration is also calculated for both models and the extreme total acceleration for model 1 and model 2 is 0.193 m/s2 and 0.209 m/s2 respectively.

Shear force calculation in PLAXIS

The shear force for the only raft and raft with pile is numerically calculated to obtain the total shear force produced at the foundation under the dynamic loading. Total shear force on the base interface, Fbase = $\sum \tau i.\ \Delta x$ (1)

The shear force calculation is shown below in tabular format_

x (m)	Δx	τ1 [kN/m]	τavg [kN/m]	τavg*Δx
53	-	-34.400	-	-
52.625	0.375	-27.864	-31.132	
52.25	0.375	-24.243	-26.053	
51.875	0.375	-20.329	-22.280	
51.5	0.375	-12.913	-16.62	
51.5	0.375	-14.615	-13.764	
51.25	0.375	-5.968	-10.2915	
50.750	0.375	0.605	-2.6815	
50.375	0.375	3.082	1.8435	
50.00	0.375	-0.563	1.2595	
48.5	-	14.223	6.83	
48.875	0.375	5.399	9.811	
49.250	0.375	-0.954	2.225	
49.625	0.375	-2.903	-1.9285	
50.00	0.375	1.49	-0.7065	
47.00	-	33.713	17.605	
47.350	0.375	28.092	30.90	
47.750	0.375	23.819	25.955	
48.125	0.375	19.345	21.582	
48.5	0.375	13.127	16.236	
	Δx=0.375		∑=8.79	=3.296kN

Sample calculation of base shear for model 2_

Similar procedure is fallowed to calculate shear force in our model 2 also; the only variation for model 2 is that shear force due to pile i.e Vpile is added into base shear at interface as given below_ , Fbase = $\sum \tau i.\ \Delta x$+Vpile (2)

Therefore by using equation (1) and (2) total shear force for model 1 and model 2 is found out to be 3.296 kN and 5.723 kN respectively.

Here shear force accumulated throughout multiplier loading was numerically calculated from the PLAXIS output. The PLAXIS output obtained at the end of the calculation phase is shown below. The fig shows the schematic shear force diagram at the raft foundation level in model 1.

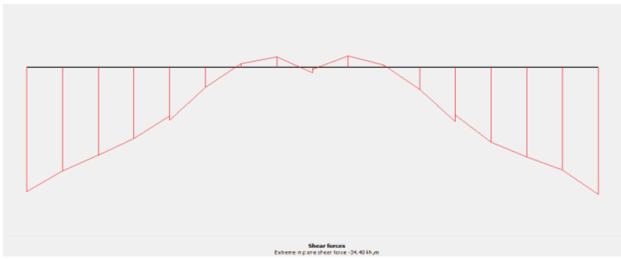

Fig. shear force diagram.

Shear force calculation using IS 1893:2002

The second objective in analysis of shear is to compare the shear force obtained from the PLAXIS with shear force calculated from IS code. In order to achieve this objective shear force using IS 1893:2002 is calculated as fallows_

The total design lateral force or design seismic base shear (VB) determined by the following expression_

V = AhW (3)

Where Ah is the design horizontal acceleration spectrum value calculated using natural period and W is seismic weight of the building. Ah is given by_

$$A_h = \frac{Z\ I\ S_a}{2\ R\ g} \tag{4}$$

Therefore by using equation (3) and (4) cited from the IS 1893:2002. Base shear force is calculated referring requisite clauses of Indian standard code for earthquake resistance building. The horizontal acceleration calculated is 0.09 and the weight of the building is total dead load of the building which came out to be 186 kN (sum of total weight of plate element defined in material properties i.e 3 kN/m) for LSM multiplied with the 1.5 factor of safety the total designed load is 279 kN and the designed shear force is found out to be 25.11 kN.

IV. CONCLUSION

The seismic response analysis of pile foundation is studied using plaxis software. For that the analysis is carried out on two different models having different foundation. the acceleration for both models are compared and it is observed that there is no significant difference in acceleration of both the models. So it is not possible to state advantage of incorporation of piles in raft foundation. The shear force calculated from plaxis output is compared with the shear force obtained from the IS code and it is observed that the shear force obtained using plaxis is much less than shear force calculated using IS code. Further shear force difference in two different models is nearly twice so it can be stated that there is increase in the percentage of base shear by incorporation of piles in raft foundation which is undesirable since higher shear force demands greater thickness of foundation.

The results for both the models are shown in table below_

Quantity	Model 1	Model 2	As per IS code
Shear force (kN)	3.296	5.723	25.11
Extreme total Acceleration (m/s^2)	0.193	0.209	-

REFERENCES

[1] Ms. Mohsin Ara Toma, " Earthquake Response Analysis of Pile Supported Structures Correspondence of PLAXIS 2D with Euro code 8 " (Trondheim, 2017).
[2] Bureau of Indian Standard (1893). Indian standard criteria for earthquake resistance design of structure general provisions and buildings. IS 1893(part 1):2002, New Delhi.

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An Experimental Study on the Effect of Zeolite and Aloe-Vera on the Properties of Concrete

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Abstract— Concrete is the vital material used in the construction industry which is composed of cement and aggregates. Cement is the main ingredient of concrete which is used as the binding material which binds aggregates together. But use of cement leads to the extreme release of CO_2 gases to the environment and leads to greenhouse effect. Alternative way should be found to control the release of CO_2 gases to the atmosphere. One of the methods is use of Zeolite powder as partial replacement to the cement. Using Zeolite not only absorbs CO_2 gases which is produced from cement but also helps to increase the strength of concrete. Here in this present study, along with the Zeolite as partial replacement to the cement, Aloe-vera gel was also used as admixture in the concrete which increases the both workability and strength of concrete.

Index Terms— Zeolite, Aloe-vera, Fresh and Hardened properties of Concrete

I. INTRODUCTION

Concrete is the combination of cement, aggregates and water. Cement is the main ingredient which is used as a binder material in the preparation of concrete in the construction industry. Yearly about 4.1 Gt of cement is produced in the world which leads to increase in the release of CO2 gas to the environment which leads to the global warming. There is a need to decrease the release of harmful gases due to the use of cement in the concrete. Here in this present study natural pozzolan Zeolite which is obtained from pozzolanic deposits was used as a replacement to cement which will absorb the harmful gases released from the cement. Use of Zeolite in the concrete will decreases the workability by absorbing water from the concrete. There is a need to increase the workability of the fresh concrete. So here in this present study Aloe vera gel is added to with water which not only increases the workability but also acts as self-curing agent. Aloe Vera gel soothing gel obtained from Aloe vera plant.

II. BACKGROUND STUDY

MeysamNajim et al., (2012) conducted investigations on durability and hardened properties of natural zeolite-based concrete. Zeolite was replaced by weight of cement (0,15 and 30%) which enhances the performance of concrete at 15%. The water absorption rate increases in zeolite concrete by 13.67% than the normal concrete at 15% of zeolite. The setting time and workability of concrete reduces by the use of zeolite because of rough surface texture and more specific surface area. The compressive strength decreases in zeolite concrete than the normal concrete but it reaches suitable strength. However, the durability properties increase in zeolite concrete at 15% replacement level.

Dzigita et al., (2016) The hardened properties of concrete were studied by replacing cement with zeolite by 0 to 10%. The water absorption rate decreases by 2.3 times, compressive strength increases by 15% for 28days of curing at 10% of zeolite and there was an increase in density. The freeze-thaw resistance also increased by 3.3times than the normal concrete and hence the durability successfully enhances. The particle size analysis was done by using SEM analysis.

Mahdi et al., (2014) study reveals that the global warming reduces by using natural zeolite a pozzolanic material. The replacement of zeolite as a cement by varying percentages 10%, 20% and 30%. The compressive strength increases up to 20% replacement level there after it starts decreasing. The compressive strength increases by 19% at 10% of zeolite at curing period of 28days than the normal concrete. The optimum replacement level was 20%. The performance of concrete in terms of durability improves even in aggressive environmental conditions also by the use of zeolite**.**

Manonmani et al., (2019) Investigated on properties of concrete by using aloe vers fiber and fly ash as constituents of concrete. The hydration reduces by the use of fly ash because of its high reactivity. The aloe vera fibers are economically effective material with various advantages such as light weight and low density. The weight of fiber fractions by weight used as 10%, 20% and 30%. The elastic modulus increases with the use of aloe vera fiber in concrete but the composites tensile strength reduces slightly.

Suvitha et al., (2018) Studied on to attain a better hydration process and long-term curing in hardened concrete by using aloe vera gel. This gel maintains moisture content in the concrete by that way reduce the water content without compromising with the quality. The slump obtained in aloe vera mixed concrete was 80mm but in normal concrete it was 68mm. Th compressive strength, split tensile strength and flexural strengths achieved in aloe vera concrete was increased by 17%, 4% and 36 % respectively at the age of 28days curing period than the normal concrete which was obtained at 2% of aloe vera. The percentage of water absorption capacity reduces in aloe vera concrete by 27% than in the conventional concrete

III. NEED OF THE STUDY

Cement is a vital material which is used in the construction industry which leads to the release of CO_2 into the environment and causes global warming. So, there is a need to control the release of CO_2 by the use of cement in the concrete. In this study Zeolite was used as partial replacement for the cement which controls the release of CO_2 but it absorbs water from the concrete which leads to low workability. To increase the workability of the concrete Aloe-vera was partially replaced to the water.

IV. OBJECTIVE OF THE STUDY

i To carry out the test on materials used in concrete as per IS specification.

ii To determine the fresh and hardened properties of concrete by using Zeolite and Aloe vera as partial replacement to the cement and water respectively

iii To find out optimum dosage of Zeolite in concrete based on strength parameters.

V. MATERIALS USED

A. Cement

Ordinary Portland cement (Birla) of 43 grade collected from RMC Hassan was used. Physical properties of Cement are given in Table 1.1

TABLE. 1.1

Sl No	Properties		Test Results	Requirements as per IS standard
1	Specific gravity		3.20	-
2	Fineness		5%	-
3	Normal Consistency		31%	-
4	Initial Setting Time		32 min	>30
5	Final Setting Time		350min	<600
6	Compressive Strength	3 Days	26 N/mm^2	>23
		7 Days	33 N/mm^2	>33
		28 Days	45 N/mm^2	>43

B. Fine Aggregate

In this study 4.75 mm downsize locally available River sand was used as fine aggregate. Physical properties of fine aggregate are given in Table 1.2.

TABLE. 1.2

Sl No	Properties	Test Results
1	Specific Gravity	2.6
2	Water Absorption	1%

C. Coarse Aggregate

Coarse aggregate of 20mm downsize was used in this study was collected from local quarry. Physical properties of fine aggregate are given in Table 1.3.

TABLE. 1.2

Sl No	Properties	Test Results
1	Specific Gravity	2.66
2	Water Absorption	0.48 %
3	Aggregate Crushing Value	25%
4	Aggregate Impact Value	27%

D. Zeolite

Zeolite (Figure1.1) used in this study was collected from online purchase. Mechanical properties of Zeolite were shown in Table 1.4.

Sl No	Properties		Test Results	Requirements as per IS standard
1	Specific gravity		2.8	-
2	Fineness		6%	
3	Normal Consistency		35%	-
4	Initial Setting Time		42 min	>30
5	Final Setting Time		400min	<600

FIGURE 1.1: ZEOLITE

E. Aloe vera

In this study aloe vera gel was used as partial replacement to the water. Aloe vera gel was collected directly from the Aloe vera plant. Slim layer tissues present in the Leaves of the Aloe vera plant is called as gel which stores the water into it.

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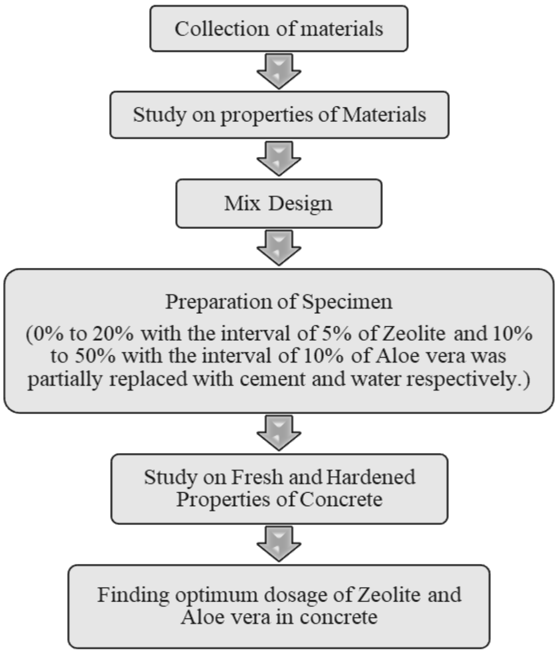
FIGURE 1.2: ALOE-VERA

VI. METHODOLOGY



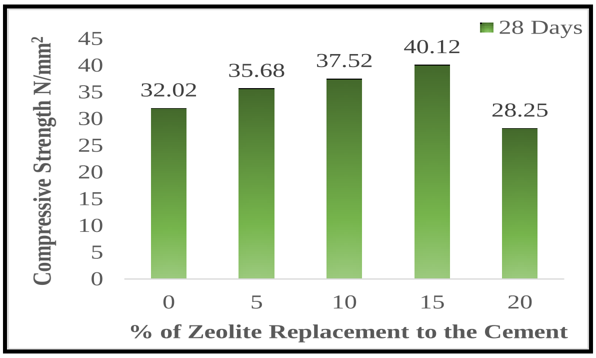
VII. RESULTS AND DISCUSSION

A. Slump Test on Concrete with and without Zeolite

GRAPH. 1.1: SLUMP TEST RESULTS

Replacement of Zeolite to the cement absorbs water from the concrete which leads to decrease in the workability. Here in the graph 1.1 shown that due to the increase in the quantity of Zeolite in concrete decreases the slump so that decreases the workability.

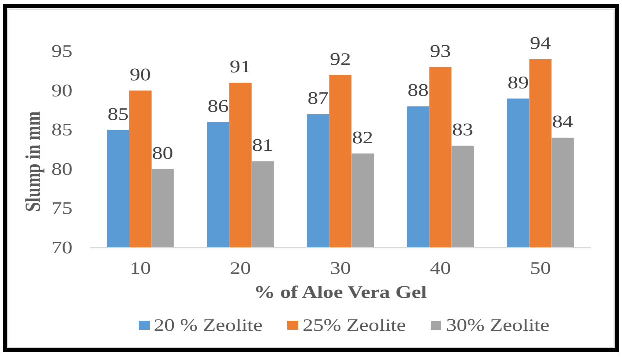
B. Compressive Strength of Concrete with and without Zeolite



GRAPH. 1.2: COMPRESSIVE STRENGTH OF CONCRETE WITH AND WITHOUT ZEOLITE

Compressive strength of concrete increases from 31.02 to 40.12 N/mm^2 with the increase in the percentage of Zeolite up to 15%. But after 15% replacement strength goes on decreases from 40.12 to 28.25 N/mm^2. this reduction in strength may be because of particle size variation and the water absorption capacity of the zeolite of the zeolite. Compressive Strength of Concrete with Zeolite and Aloe vera

C. Slump Test on Concrete with and without Zeolite and Aloe vera

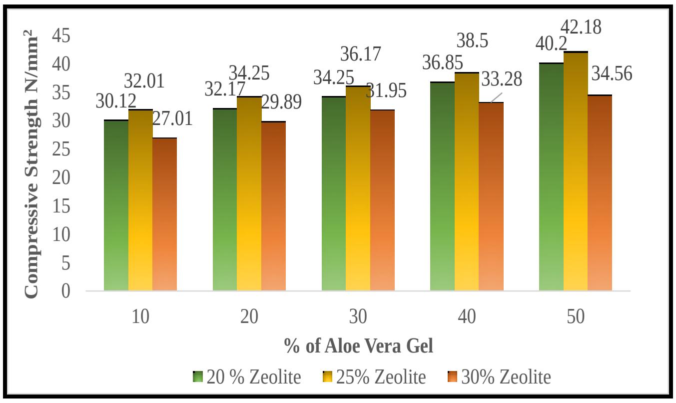


GRAPH. 1.3: SLUMP TEST RESULTS

Due to the increase in the percentage of Zeolite and Aloe vera gel in concrete increases the slump so that increases the workability.

D. Compressive Strength of Concrete with and without Zeolite and Aloe vera.

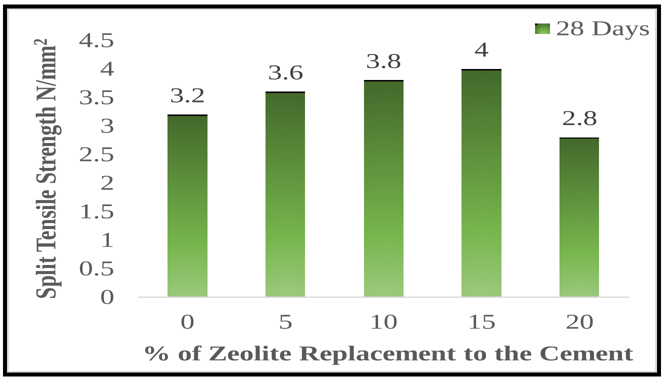
From the graph 1.2 it was shown that there is a decrease in the compressive strength of concrete while replacing 20% of Zeolite to the cement. It may be due to the dryness of concrete ass zeolite absorbs water from the concrete. Here in this study an attempt was mad to reduce the dryness of concrete by adding Aloe vera gel as partial replacement for water. To check the result again the zeolite percent was increase up to 30% with 5% interval.



GRAPH. 1.4: COMPRESSIVE STRENGTH OF CONCRETE WITH AND WITHOUT ZEOLITE AND ALOE VERA

Graph 1.4 shows the variation in the compression strength of concrete with and without Zeolite and Aloe vera. With the addition of Aloe vera to the concrete with 20, 25 and 30% of zeolite increases the compression strength. Compression strength gradually increases with the increase in the percentage of Aloe vera.

E. Split Tensile Strength of Concrete with and without Zeolite

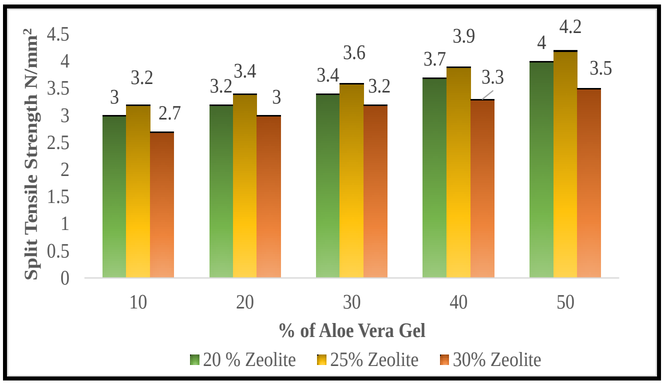


GRAPH. 1.5: SPLIT TENSILE STRENGTH OF CONCRETE WITH AND WITHOUT ZEOLITE

Split Tensile strength of concrete increases from 3.2 to 4 N/mm^2 with the increase in the percentage of Zeolite up to 15%. But after 15% replacement strength goes on decreases from 4 to 2.8 N/mm^2. This reduction in strength may be because of particle size variation and the water absorption capacity of the zeolite.

F. Split Tensile Strength of Concrete with and without Zeolite and Aloe vera.

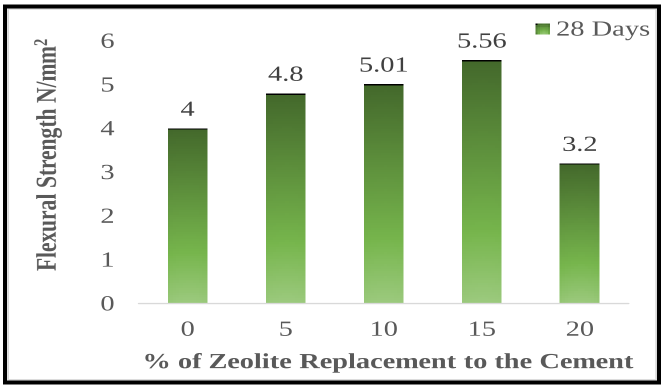
Graph 1.6 shows the variation in the split tensile strength of concrete with and without Zeolite and Aloe vera. With the addition of Aloe vera to the concrete with 20, 25 and 30% of zeolite increases the split tensile strength. split tensile strength gradually increases with the increase in the percentage of Aloe vera.



GRAPH. 1.6: SPLIT TENSILE STRENGTH OF CONCRETE WITH AND WITHOUT ZEOLITE AND ALOE VERA

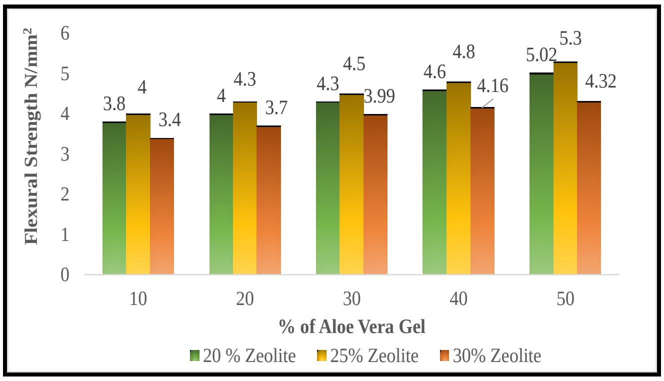
G.Flexural Strength of Concrete with and without Zeolite

Flexural strength of concrete increases from 4 to 5.56 N/mm^2 with the increase in the percentage of Zeolite up to 15%. But after 15% replacement strength goes on decreases from 5.56 to 3.2 N/mm^2. This reduction in strength may be because of particle size variation and the water absorption capacity of the zeolite.



GRAPH. 1.7: SPLIT TENSILE STRENGTH OF CONCRETE WITH AND WITHOUT ZEOLITE

H.Flexural Strength of Concrete with and without Zeolite and Aloe vera.



GRAPH. 1.8: SPLIT TENSILE STRENGTH OF CONCRETE WITH AND WITHOUT ZEOLITE AND ALOE VERA

Graph 1.8 shows the variation in the Flexural strength of concrete with and without Zeolite and Aloe vera. With the

 ISBN: 978-93-90214-19-8

addition of Aloe vera to the concrete with 20, 25 and 30% of zeolite increases the split tensile strength. Flexural strength gradually increases with the increase in the percentage of Aloe vera.

VIII. Conclusions

- Slump goes on decreases with the increase in the replacement of Zeolite to the cement. Zeolite absorbs water from the concrete due to which slump get decreases.
- Slump get increases when Aloe vera gel is replaced with the water in the concrete with zeolite. Aloe vera returns the water content to the concrete which was absorbed by the zeolite and helps to increase the workability of the concrete.
- Compression strength, Tensile Strength and Flexural Strength of the concrete increases with the increase in the Zeolite content up 15%, after that strength will decreases. It may be because of particle size variation and the water absorption capacity of the zeolite.
- Compression strength, Tensile Strength and Flexural Strength of the concrete increases with the increase in the Zeolite and Aloe vera Content in the concrete.
- Study finally concludes that use of Zeolite and Aloe vera increases the strength of the concrete and use of Zeolite in the concrete absorbs CO2 from the concrete which was releases by cement.
- Use of Zeolite and Aloe vera in the concrete proves to be environmentally friendly.

REFERENCES

i Najimi, M., Sobhani, J., Ahmadi, B., & Shekarchi, M. (2012). An experimental study on durability properties of concrete containing zeolite as a highly reactive natural pozzolan. Construction and Building Materials, 35, 1023–1033. doi:10.1016/j.conbuildmat.2012.04.038

ii Nagrockiene, D., & Girskas, G. (2016). Research into the properties of concrete modified with natural zeolite addition. Construction and Building Materials, 113, 964–969. doi: 10.1016/j.conbuildmat.2016.03.133

iii Valipour, M., Yekkalar, M., Shekarchi, M., & Panahi, S. (2014). Environmental assessment of green concrete containing natural zeolite on the global warming index in marine environments. Journal of Cleaner Production, 65, 418–423. doi: 10.1016/j.jclepro.2013.07.055

iv Manonmani P. N., Arulmani C., Kaarthickumar K., Udhayakumar P., Vijaykumar T., (2019) "Experimental Study On Aloe Vera Fiber Concrete with Admixture" International Journal of Scientific & Engineering Research Volume 10, Issue 3, 40-43.

v P. Suvitha, K.B. Tharanishkrishna, S. Raju, G. Desinguraja and S. Lakshmanarayanan (2018) "Experimental Investigation On Strength Properties of Self Uring Concrete Incorporated with Polymeric Material as Self Curing Agent" Indian J.Sci.Res. 20(2): 165-170.

vi Shiva Ji Gond., AkhandPratap Mitra., Sandeep Yadav., Jayprakash Yadav., and Virendra Kumar Saxena. (2020) "Use of Zeolite Powder as a Supplement of Cement in Concrete: A Review" International Research Journal of Engineering and Technology, Volume: 07 Issue: 05. 5089-5095.

Analysis and Design of high rise building with and without outrigger beam system-A Review

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Abstract— ***The construction of high rise building is rapidly increasing worldwide. Major challenge in designing high rise (tall) structure is ensuring its lateral stability. Tall structures are usually critical to lateral loads such as wind and earthquake. So, it is very important to design a high rise structure with sufficient strength and safety against lateral loads. When the building increases in height, the stiffness of the structure becomes more important as height of the building increases, the stiffness of the building reduces so, by providing outrigger beams between the core and external column is often used to provide adequate lateral stiffness to the structure. Outrigger beam system is one of such a system which is developed especially for tall structure to effectively control the excessive drift due to lateral loads. In this paper, study of literature is review on analysis and design of high rise building with and without outrigger beam system in terms of various parameters like lateral displacement, storey drift and base shear that play a crucial role in a finding the behavior of a structure against the lateral loads and optimum location of outriggers in a high rise building.***

Index Terms—***Lateral Load Resisting System, Outrigger Beam System***

I. INTRODUCTION

In today's world, tall buildings are becoming more and more slender, which leads to the possibility of more sway contrasting to older tall buildings. This has made engineers think very acutely about the effect of lateral loads which will affect its height and also an advancement necessitate in the use of frame structural system [1]. At the point when the tall structure begins developing higher, they face up to various concerns like material selection, wind and earthquake governing, and other factors. From the structural point of view when the high-rise building started growing, they faced a lot of structural stability issues governed by wind and ground motions [2]. The design of tall and slender structures is regulated by three governing factors, strength (material capacity), stiffness (drift), and serviceability (motion perception and accelerations), produced by the action of lateral loadings, such as wind, earthquake [3]. To resist lateral forces, there are a number of load resisting structural systems which are usually assimilated in multi-storied structures. When the height of the building increases tall buildings with only shear walls are not proficient of resisting large lateral forces when it goes to top levels. So it is essential to provide an extra structural element in accordance with the shear wall which reduces the total seismic effect on the structure. Outrigger beam system has proven one of the best structural systems to effectively control the excessive drift due to lateral loads [4].

An outrigger is a stiff beam that connects the shear walls to exterior columns. It is provided to improve the overturning stiffness and strength of high rise building. When the structure is exposed to lateral forces, the outrigger and the columns withstand the rotation of the core and hence particularly reduce the lateral deflection and base moment, which would have arisen in a free core [5].

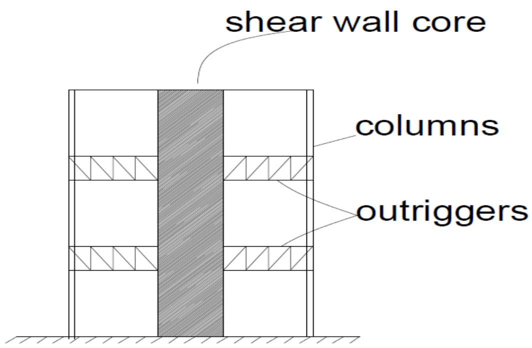

Fig.1 Outrigger beam system [6]

II. PERFORMANCE OF OUTRIGGER BEAM SYSTEM

Outriggers are the horizontal members which connect the interior core of the structure to the Outermost columns and hence it helps to resist the lateral loading [7]. Outrigger systems are generally very effective in executing the serviceability requirements of tall buildings [8]. When a structure is subjected to laterals loading, outriggers transfer the rotational forces from the building core to the outermost columns, this process changes the horizontal forces to vertical forces i.e. tensile and compressive forces [9]-[10]. Outrigger beams between the shear wall and exterior column are often provided to achieve sufficient lateral stiffness of the structure. Outrigger beams connected to the shear wall and external columns are relatively more complicated and the performance of such coupled wall systems depends primarily on adequate stiffness and strength of outrigger beams. Therefore, overall rigidity is imperative in tall buildings to control lateral deflection and inter-story drift [1]. Outrigger structural system is experienced in controlling top displacement as well as plays a crucial role in reducing inters story drift. Flexural stiffness is increased by the outrigger structure but it does not increase its resistance to shear which has to be carried by the core [11]. When the lateral forces acting on a building, the outrigger resists the rotation of the core and thus reduce the lateral displacement and base moment. To increase stiffness action against wind and seismic load outriggers are provided by the shear core with exterior frames in tall structures [12].

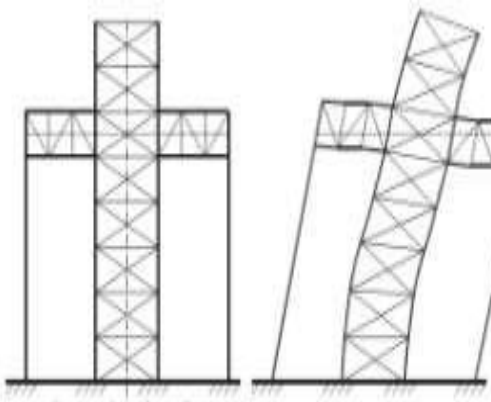

Fig.2 (a) Performance of outrigger system against lateral load paper [13]

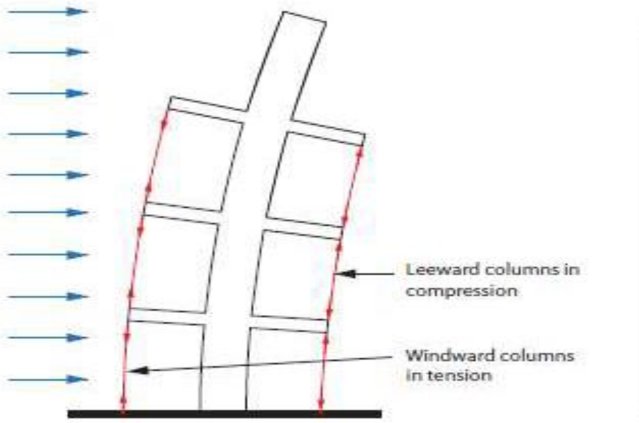

Fig.2 (b) Behavior of outrigger beam system [14]

III. LITERATURE REVIEW

Technical papers of various journals from India and abroad are studied to understand the importance and necessity of this research in consideration of wind and seismic resistant Design. It presents a summary of the literature review. The following review of the Literature gives an outlook on the behavior of outrigger structural systems in a high-rise building.

S.Fawzia Examined the effect of cyclonic wind and provision of outrigger on 28 stories,42 stories, and 57 stories high rise buildings and they concluded that plan dimensions had influential effects on structural heights. An increase in height while keeping the plan dimensions the same, causes the reduction in lateral rigidity. To achieve the required stiffness increase of bracing sizes as well as the introduction of an additional lateral resisting system such as belt truss and outrigger is required [8].

Divya Bhuta Investigated a 40 story RC structure space frame using different lateral loads resting systems used in high-rise buildings such as a shear wall, outrigger, and dia-grid. Analysis has been carried out using a different method (response spectrum analysis and time history analysis) to understand the behavior of shear wall, outrigger, and dia-grid system under dynamic load effect. They concluded that in the seismic co-efficient method the % difference of lateral displacement is more and lesser in the response spectrum method; the Model using the diagrid system shows minimum displacement in comparison to other models in time history analysis also they concluded that the outrigger system reduces Overall drift compared to other systems. Variation in drift noticed where the outrigger connected to the core [1].

N.herath Investigated the optimum outrigger location in a 50 storey reinforced concrete building under earthquake loads

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for Response spectrum analysis, three different peak ground acceleration to peak ground velocity ratios in each category of earthquake records were incorporated. Response spectrum analysis was conducted and the behavior of the building was determined considering response parameters such as lateral displacement and inters storey drift. It has been observed from this study that the optimum outrigger location of a high rise building under the action of earthquake load is between 0.44-0.48 times the height of the building (from the bottom of the building)[15].

Abbas Haghollahi et al. Studied Optimization of outrigger locations in steel tall buildings subjected to earthquake loads. Two models of 20 and 25 story high-rise steel frame buildings have been investigated to compare optimum outrigger locations obtained by response spectrum and nonlinear time-history analysis. Response spectrum and time-history analyses have been carried out against seven ground motions. They found the optimized location of the outrigger with nonlinear time-history is different from response spectrum analysis. Optimum location of outrigger and belt truss resulted from response spectrum analysis for 20 and 25 story models are story 10 and 14 respectively [14].

Nehal M.Ayash –Studied the optimum location for one or double internal outrigger with cap outrigger in 55 story RC buildings the nonlinearity effects are taken into consideration. They showed that response spectrum analysis underestimated the responses; while the linear time history analysis overestimated the results when compared with non-linear time history. The optimum locations for single and double internal outriggers with cap one are at (0.67, 1) and (0.67, 0.75, 1) of building height, respectively [13].

P.M.B. Raj Kiran Nanduri et al. Studied Optimum position of outrigger system for high-rise reinforced concrete buildings under wind and earthquake loadings. Analysis has been carried out on 30-story three-dimensional models of RC building with outrigger and belt truss to find the lateral displacement reduction. The design of wind load and earthquake load was calculated based on IS 875 (Part 3) and IS 1893 (Part-1): 2002 respectively. They observed that Maximum drift at the top is 50.6mm, 48.20mm, and 47.6mm for core without any outrigger, outrigger with belt truss, and outrigger without belt truss, using a second outrigger with cap truss gives the deduction reduction of 18.55% and 23.01% with and without belt truss. The optimum location of the second outrigger is at the middle height of the building [3].

S.Fawziate et al. Analyzed deflection control by effective utilization of belt truss and outrigger system on a 60-storey composite building subjected to wind loads. A three-dimensional Finite Element Analysis is performed with one, two, and three outrigger levels. The reductions in lateral deflection are 34%, 42%, and 51% respectively as compared to a model without any outrigger system. The author showed that the best location for one outrigger option is at level 36, i.e. 0.6 times the height of the structure. The best location for the second outrigger of two outrigger systems is 0.5 times the structure height while one is fixed at the top level [16].

CONCLUSION

From literature review, it has been observed that

1. Lateral load resisting structural system such as rigid frame system braced frame system shear wall frame system, tube system, and outrigger system, it was found that outrigger structural system is effective in controlling top displacement as well as plays an essential role in reducing inter-story drift. It is suggested that Outrigger system is efficient up to 60 storey High-rise building.
2. Stiffness and stability against lateral loads caused by wind and earthquake will improve by implementing outrigger beam in High-rise buildings.
3. Outrigger performs an essential role in improving the structural flexural stiffness by reducing base shear when the structure is subjected to earthquake static and dynamic loads.
4. The optimum outrigger locations of the building have to be carefully selected in the building design. The location of the outrigger beam has a critical influence on the lateral behavior of the structure under earthquake load.
5. The optimum position of the outrigger at mid-height shows the maximum reduction in lateral deflection in the building.

REFERENCES

[1] D. C. Bhuta and U. Pareekh, "Comparative Study on Lateral Load Resisting System in Tall Building," vol. 2, no. 11, pp. 320–327, 2016.

[2] K. A., A. Batra, and S. Gupta, "Analysis of Tall Building With Different Lateral Force Resisting System," *Int. J. Innov. Res. Comput. Sci. Technol.*, vol. 8, no. 3, pp. 174–181, 2020, doi: 10.21276/ijircst.2020.8.3.26.

[3] P. . M. B. R. K. Nanduri, B. Suresh, and I. Hussain, "Optimum position of outrigger system for high-rise reinforced concrete buildings under wind and earthquake loadings," *Am. J. Eng. Res.*, vol. 02, no. 08, pp. 76–89, 2013, [Online]. Available:

[4] A. Sundaresan and A. Suresh, "Comparison of Building in Sloped Area with and without Outrigger," pp. 4477–4480, 2019.

[5] K. Kamath, A. A. R., and S. Upadhyaya K., "A Study on the performance of multi-outrigger structure subjected to seismic loads," *J. Mech. Civ. Eng.*, no. August, pp. 27–32, 2014.

[6] Md Safee Sohail, Prof. Md Mansoor Ahmed, and Prof. Shaik Abdulla, "Optimization of Multistory Building with

Multi-Outrigger System and Belts Truss,” *Int. J. Eng. Res.*, vol. V5, no. 07, pp. 509–516, 2016, doi: 10.17577/ijertv5is070465.

[7] P. Sharma and G. Singh, “Dynamic analysis of outrigger systems in high rise building against lateral loading,” *Int. J. Civ. Eng. Technol.*, vol. 9, no. 8, pp. 61–70, 2018.

[8] S.Fawzia, A.Nasir and T.Fatima, “A Study of the effectiveness of Outrigger System for high-rise composite buildings for cyclonic region ,” *World academic of science, engineering and technology , pp 60,2016*.

[9] Varsha Virde, Dr.R.Singh, Alok Rathore “Analysis of high-rise building with outrigger using non-dimensional parameters,” *Int. J. Adv.Res. Eng. Technol.* ,vol. 11, 2020.

[10] Sreelekshmi.S, Shilpa Sara Kurian“ Study of Outrigger Systems for high-rise Buildings,” *Int. J. Innov.Res. Sci.Eng.Technol.*, vol. 5, Issue 8, August 2016.

[11] K. Kamath, “A Study on Static and Dynamic Behavior of Outrigger Structural System for Tall Buildings,” *Bonfring Int. J. Ind. Eng. Manag. Sci.*, vol. 2, no. 4, pp. 15–20, 2012, doi: 10.9756/bijiems.1655.

[12] R. Khandelwal and R. Singh, “Optimum Shape and Position of Outrigger System for High Rise Building under Earthquake Loading,” *Int. J. Innov. Technol. Explor. Eng.*, vol. 9, no. 3, pp. 3268–3275, 2020, doi: 10.35940/ijitee.c8961.019320.

[13] A. Haghollahi, M. B. Ferdous, and M. Kasiri, “Optimization of outrigger locations in steel tall buildings subjected to earthquake loads,” *Proc. 15th World Conf. Earthq. Eng.*, 2012.

[14] N. M. Ayash and M. H. Agamy, “Non-linear seismic analysis of high raised RC buildings with outrigger systems,” *Int. J. Sci. Eng. Res.*, vol. 10, no. 1, pp. 40–52, 2019, [Online]. Available: http://www.ijser.org.

[15] N. Herath, N. Haritos, T. Ngo, and P. Mendis, “Behaviour of outrigger beams in high rise buildings under earthquake loads,” *Aust. Earthq. Eng. Soc. 2009 Conf.*, 2009, [Online]. Available: http://www.aees.org.au/wp-content/uploads/2013/11/Herath-et-al.pdf.

[16] Sabrina Fawzia and Tabassum Fatima, “Optimum position of steel outrigger system for high-rise composite buildings subjected to wind loads.,” *Adv.steel constr.*, vol. 12, no. 2, pp. 134-153, 2016.

Simulation of Flow over Single-Step Broad Crested Weir Using HEC-RAS

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Abstract - In this study, the free flow over the singe-step weir was simulated using of HEC-RAS 4.1 software. This software was used to compute the water surface profile. It was found that HEC-RAS could capture the overall features of the flow profile over the weir with reasonable accuracy. Besides, HEC-RAS was found easy to use for this Specific flow problem and performed the computations in a short time.

Keywords: single-step weir, HEC-RAS, water surface profile.

INTRODUCTION

Many hydraulic structures are constructed in an open channel according to the purpose and the nature of the regime. Weir is one of this structures which used for discharge measurement as well as rising water depth in irrigation channel.

Today with the improved numerical algorithm and the increasing computing power, using software became essential for solving hydraulic problems. The software can be used as an effective tool for many purposes, such as to evaluate the designs of existing and proposed structure, predict structure performance under different flow conditions, and perform hydraulic calculations for the entire flow field at a cost and time less than physical modeling

A large number of computer models are available for simulating the hydraulic problems. It is therefore important that engineers have sufficient knowledge of the abilities and limitations of the models s as to select the suitable software for solving specific flow problems.

One of the most common computer models is the one-dimensional River Analysis System (HEC-RAS) developed by Hydrologic Engineering Center of the US Army Corps of Engineers (USACE).

For the purpose of the study, the studies that have evaluated the performance of HEC-RAS are reviewed herein.

The preceding review shows that HEC-RAS has mostly been used to model floodplains and channels and it has rarely been evaluated to describe weir flow problems. In the present study, the one-dimensional steady flow module of HEC-RAS was used to develop the water surface profile. It was a major purpose of the present study to discover the advantages and limitations of HEC-RAS for simulating the flow over a stepped hydraulic structure

2. OBJECTIVES

Objectives are to be followed:-

a) Developed the soft model of rectangular channel with single step weir in it and run the different discharges in the channel.

b) To determine the water surface profile for different discharges over single step weir.

3. APPROACH:-

This research is a computer based study which involves two data sets; geometrical data and a hydraulic data. Geometrical data sets will go through the geometrical data tools. The next step is to feed a hydraulics data it will go through steady flow component.

4. SINGLE-STEP WEIR DIMENSIONS:-

For the following dimensions (Table 1) of rectangular channel and single-step weir, soft model is developed in HEC-RAS.

Table 1:- Dimensions of single-step weir and rectangular channel.

	Base(b)	Depth (d)	Width (w)
Rectangular channel	471cm	60cm	30cm
Single step weir	60cm	30cm	30cm

5. HEC-RAS

HEC-RAS is a one-dimensional steady flow hydraulic model designed to aid hydraulic engineers in channel flow analysis. The Hydrologic Engineering Centre's River Analysis System (HEC-RAS) software has been developed by the U.S. Army Corps of Engineers and has been made available for public use, free of cost. The Hydrologic Engineering Centers-River Analysis System (HEC-RAS 4.1) has been used in this study for numerical modeling of single step weir. HEC-RAS contains computational routines that handle inline structures, bridges, culverts, lateral structures, and off channel storage. All of these components can be used during modeling. HEC-RAS computes profiles in steady and unsteady flow.

6. MODEL DEVELOPMENT

HEC-RAS requires the geometry of the channel to be input by a series of cross sections. The cross sections need to be refined enough to adequately describe the channel. Channel and overbank roughness values must be assigned for each cross section in the model, and should adequately represent the bed material, bed forms. A schematic representation of the HEC-RAS model of Single step weir is shown in figure. There was 25 cross sections. Apart from this, the contraction and expansion loss coefficients were also required as input data. These values were represented by a 0.1 and 0.3 respectively.

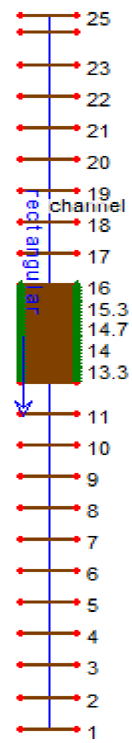

Fig.no.(1) HEC-RAS schematic plan of channel.

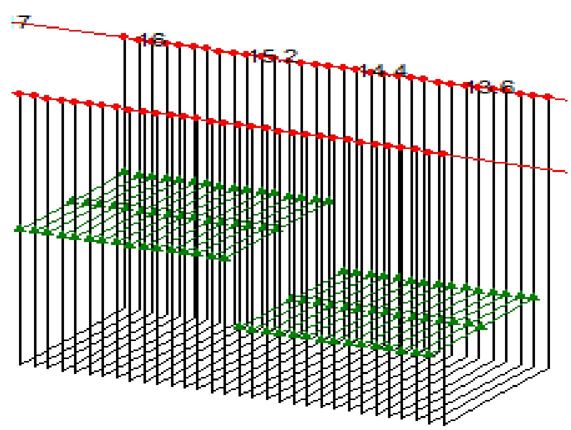

Fig.no. (2) plan of single step weir

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Using the ineffective flow area option, the single step was positioned in the channel. And put all the cross section in a cross section data box.

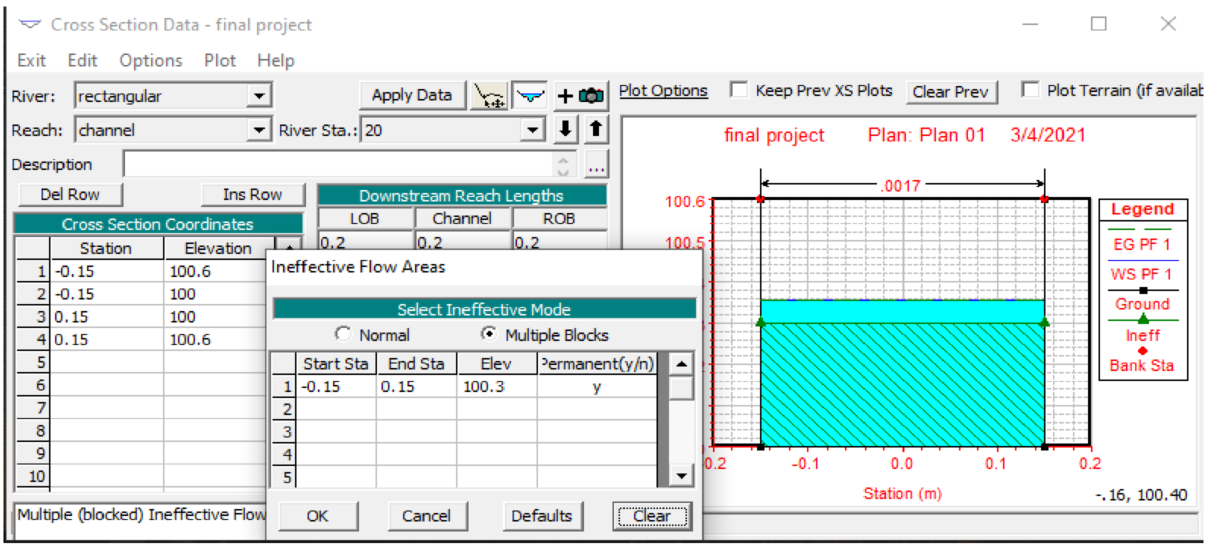

Fig.no.3) cross section data box, Table of Geometric properties for a cross section in HEC-RAS

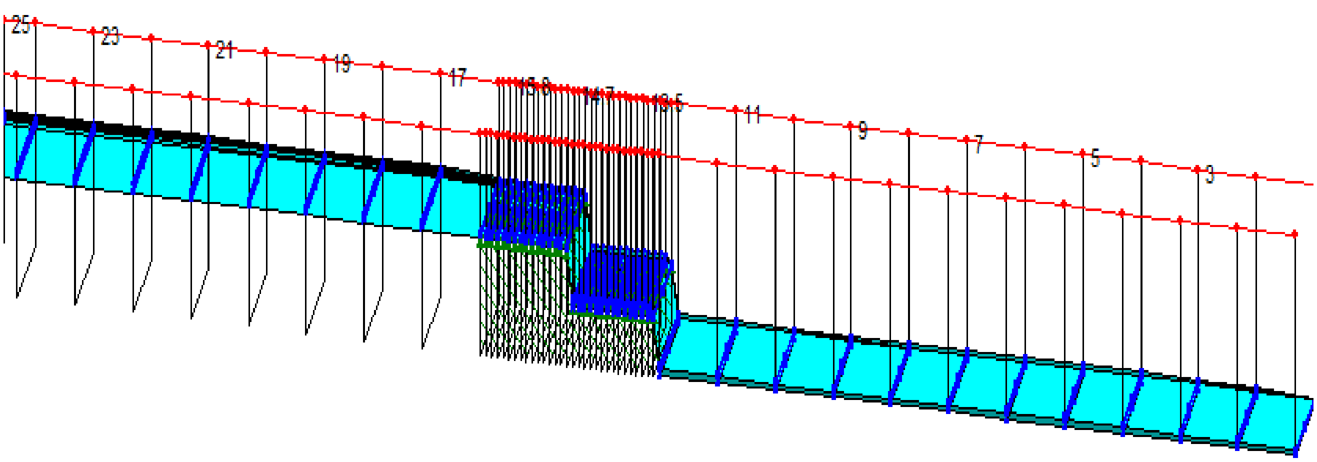

Fig. no.4). Perspective view of single step weir in HEC-RAS

7. Steady flow data:-

Steady flow data is defined for the reach. Flow data in HEC-RAS model consists of the flow rate and boundary conditions. After entering the geometric data and before the steady flow simulation, the flow data and the boundary conditions were entered. Boundary conditions of normal depth options were

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defined at all of the external ends of the system. The data feed into steady flow data editor is as shown in Figure.

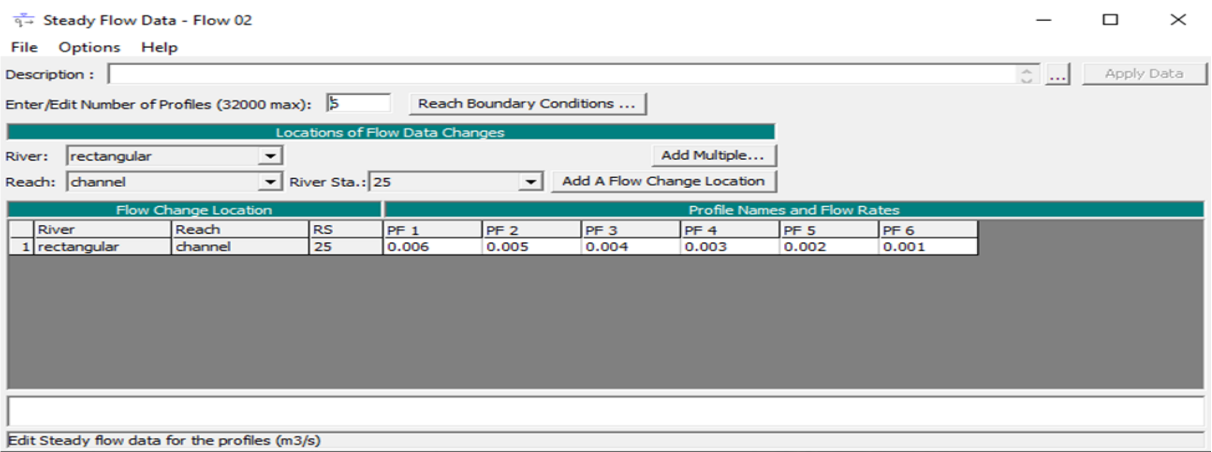


Fig. no. 5. Steady -Flow data editor of HEC-RAS 5.0.7

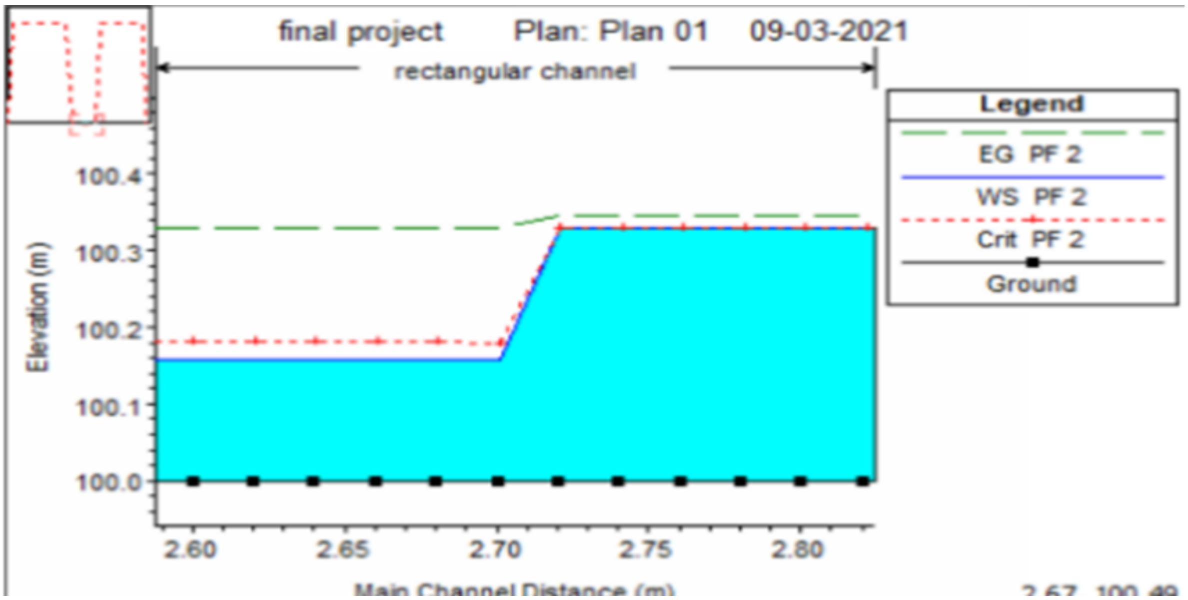
As a mixed flow regime was considered, both upstream and downstream boundary conditions were required to be provided. These were taken as normal depth and average energy slope as 0.0004. Profile calculations are performed using the standard-step procedure.

8. Computational time:-

The theoretical bases and the solution techniques of the HEC-RAS model are determining factors of the time of computations. In the present simulations, HEC -RAS spent a maximum time of less than (30) seconds to compute the water surface profiles over the weir.

9. Water surface profiles and perspective plot for single step weir in rectangular channel.

Water Surface profiles and perspective plot using HEC-RAS for single step weir in rectangular channel is shown in Figure.



10. Conclusion:-

The following conclusions may be drawn:

a) HEC-RAS could compute the water surface profile of the single-step weir very well.

b) HEC-RAS could simulate accurately the water surface profile over the upper part of the single-step weir.

c) HEC-RAS could not simulate the curved flow past the vertical faces of the single-step weir.

d) HEC-RAS is easy and friendly to use. It demands few boundary conditions data and required no initial conditions. The geometric data file for this specific flow problem was also found easy to create and modify.

e) HEC-RAS computes the one-dimensional free-flow surface profiles very quickly. The computation time was less than a half minute.

However, the performance of the steady-flow module of HEC-RAS on the single-step weir is expected to be the same for a multi-step weir flow problem.

REFERNCES:-

Jihan Mahmood Quasim 2006-2013 HEC-RAS simulation of single step weir, university of Duhok,Duhok,Iraq.

Dr. Hamid H.Hussein,saleh J.S. 2009 Flow characteristics and energy dissipation over single step broad-crested weirs .university of mousl.

Badar AM, ghare AD (2013) Simulation of simple cylindrical flume in trapezoidal channel,

Shaker Abduatif Jail and Jihan Mahommad Quasim 2016 Numerical modeling of flow over single-step broad crested weir using FLOW-3D AND HEC-RAS, university of duhok ,Iraq.

ISBN: 978-93-90214-19-8

Ageing Water Storage Reservoirs: An Overview of Emerging Risk in India

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Abstract - India is an agrarian country, now and then, and dams are called an engine of agricultural growth. These water reservoir structures are built to store the flowing river water and use it for various intended purposes, including irrigation as a prime purpose. India has 5264 large dams, which stands at third position after China and the USA. These structures not only create the irrigation potential but also cater to the myriad needs of the people. On the contrary, the dam can result in a calamity to the habitats on the downstream side when a breach occurs. Inspection and maintenance of large dam have always been a matter of concern due to their complexity and location. Many such water storage structures have attained more than 50 years; in addition to it, about 4.5 thousands of Dams are having an average age of 42 years and the median age of 41 years. These ageing dams are posing threat to the infrastructures, livelihood, ecology & environment and ultimately the people of ordinary residence of the province and have emerged as a major risk in India. Besides ageing, adverse environmental events have added worry towards its breach or failure. This paper highlights the state of ageing dams in India with an overview of ageing safety needs in various regions of the country. The paper concludes with recommendations for immediate steps to take for mitigating the risk.

Keywords: Dam, Large Dam, Failure, Water Storage Reservoirs, Risk

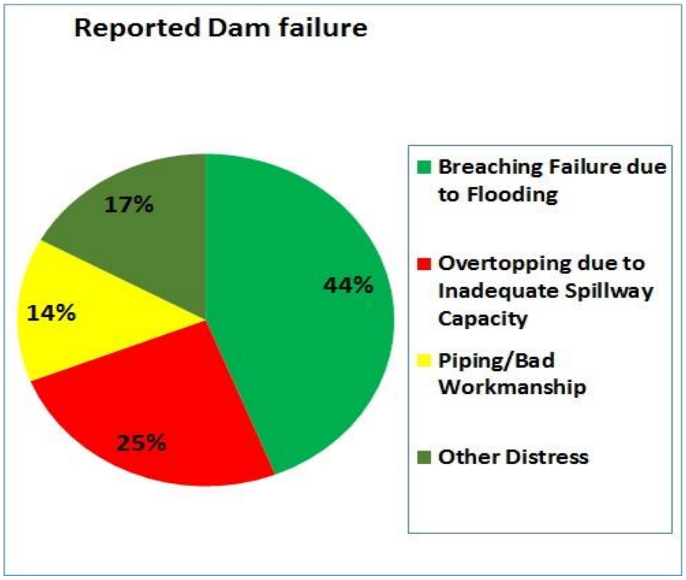
Introduction

Agriculture is an ancient business of a country like India for which the government has begun the construction of large dams on Indian rivers since the mid-nineteenth century. The momentum for dam construction took in the early twentieth century. By the end of the year 2020, India has built a total of 5264 and 437 large dams are under construction (Nicobar, 2018). Nevertheless, China and the United States of America has close to 24000 and 1000 large dams respectively to their credit; making India stand third in the world in creating water storage infrastructure (Perera et al., 2021). The majority of large dams in India are old now with an average age of 42 years and the median age of 41 years (Perera et al., 2021). The entire countries put together have built almost 45000 or more large water storage reservoirs across 50 per cent of rivers that flow in the respective geographical area (Bid & Siddique, 2019).

These dams are considered as a lifeline for agriculture business and were designated as "Temples of Modern India" by Jawaharlal Nehru, the first Prime Minister of India. Multipurpose activities such as irrigation, hydropower, fisheries, drinking water, water for industrial use, flood routing, green cover development, groundwater recharge, etc. are fulfilled by having a large dam on rivers (Bid & Siddique, 2019). Tenet of the serviceability and durability of large warrants proper inspection and maintenance of the structure, especially, those dams heading towards ageing criterion.

The international commission on the large dam, in its comprehensive report, brought important facts about the failure of large dams. It mentioned that about 2.2 percentages of all dams that were constructed before 1950 have failed, which forms a part of 200 prominent part of dam failure events until the year 1965 across the globe. Common failures of dams were attributed to operational problems, seepage, settlement under pressure, besides filling of the dam at the beginning and end (Sataloff et al., n.d., Perlea, 1984).

As per the record of the Central Water Commission of India, the country also shared the global statistics of dam failure with its maiden failure of Tigra Dam built on Sank river of the then central province in the year 1917. Based on loss of lives, the most terrible failure was of Machchhu Dam in the year 1979 built over Machhu river in Morbi district of Gujrat. Year-wise dam failures in India are presented in graphics below:



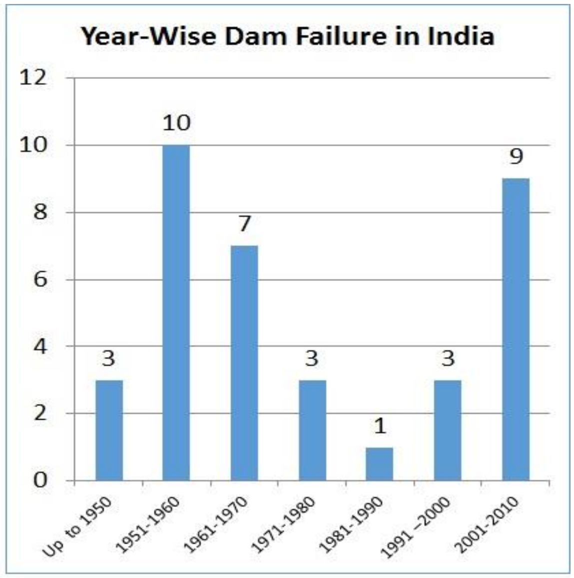


Fig.1 Dam failures in India-cause and year wise data *(Source: Central Water Commission of India)*

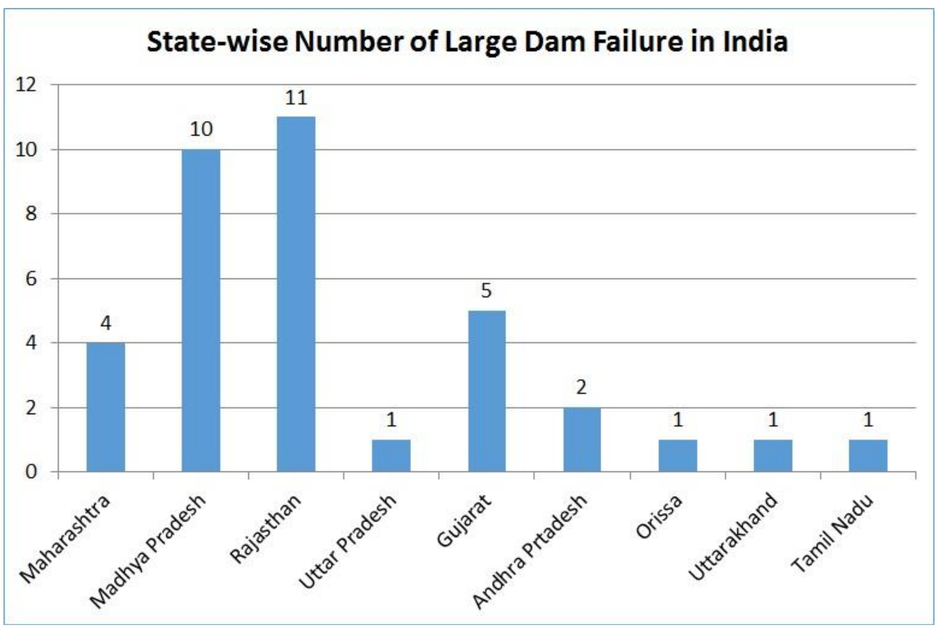


Fig.2 State-wise Dam failures in India *(Source: Central Water Commission of India)*

Large Dams in the States of India – an overview

Principally, the large dam is the water storage structure having been constructed with a total height of more than 15 to 100 meters between the crest of the dam and the bottom of the foundation, out of which dams with a height of 100 meters are designated as dams of national importance. Such dams are having a large water storage capacity to the tunes of a billion cubic meter (Nicobar, 2018). The

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States in India enjoys the autonomy to create, manage, and administer water storage infrastructures. Depending upon the need arises to cater the water for irrigation, industry and drinking, the state governments propose the water infrastructure to construct. Once the dam is constructed, it is the responsibility of the dam safety organization including the chief engineer of the local circle to inspect and maintain the dam during the pre and post-monsoon period. State-wise information on large dams in India are given below:

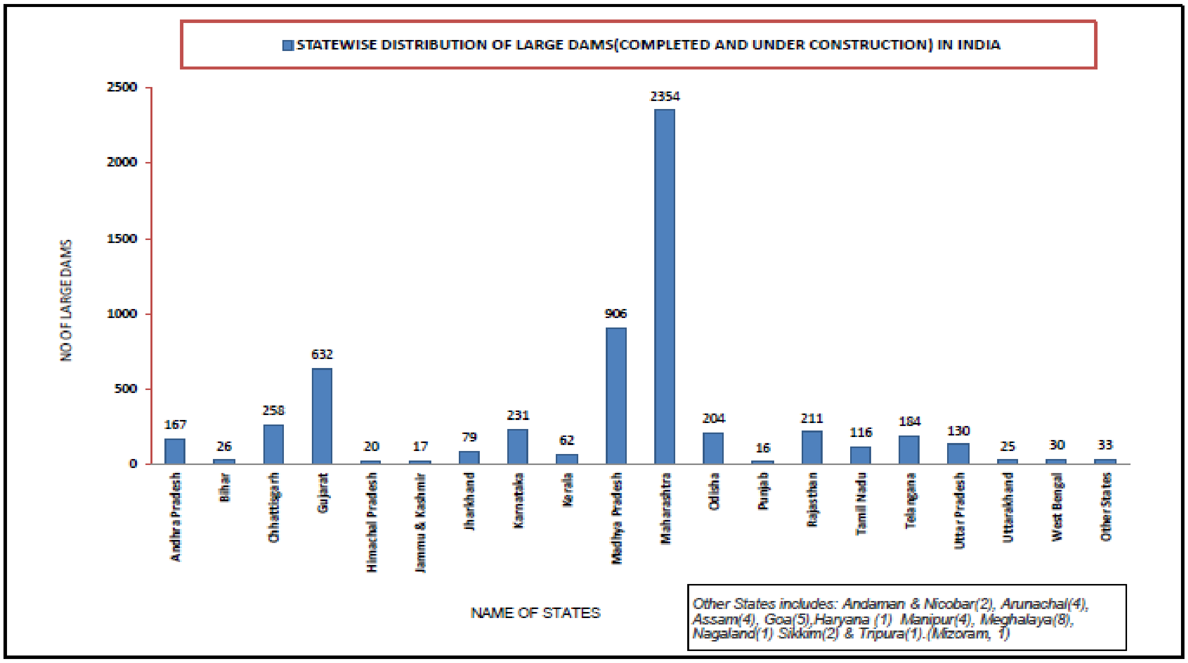

Fig.3 State-wise information of large dams in India (Nicobar, 2018)

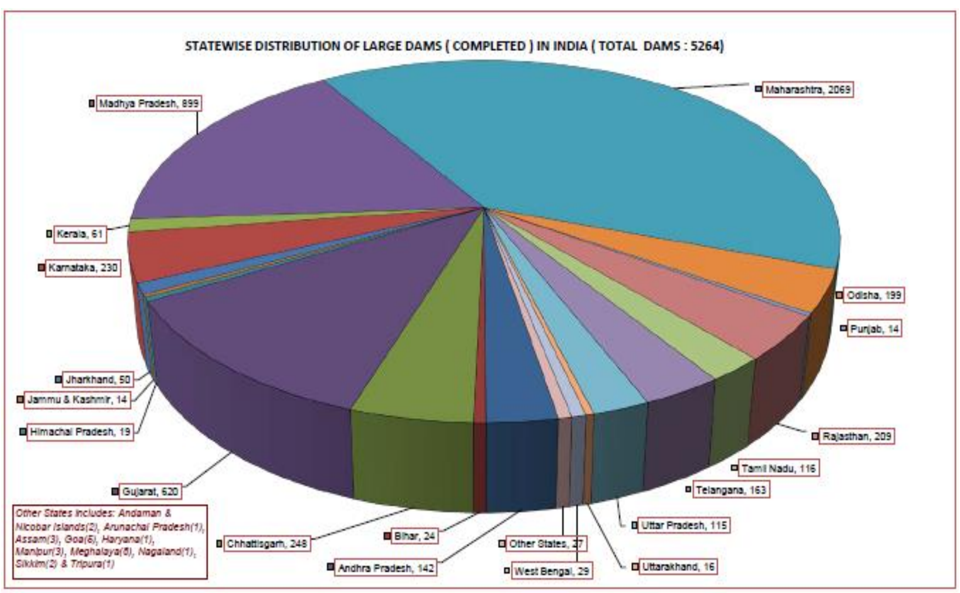

Fig.4 State-wise information of large dams in India (Nicobar, 2018)

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Role of Extreme Geological, Environmental Events and Climatic Conditions in Failure of Dams in India

The stability of our ecosystem is dependent on healthy environmental conditions and its sustenance (CWC, 2012). Undoubtedly, the construction of a large dam do create an impact on the ambient environment, geology and local habitats, but through stringent environmental management strategies, the impact needs to be taken care of. If we fail to implement the environmental management strategies effectively and protect the environment, then extreme events can cause serious harm to the water storage infrastructure falling in the catchment area. Similar is the situation in hilly glacial basins in India; where big lakes out of melting of glacial forms (Directorate et al., 2017). Moreover, the rivers flow in an abundance of water due to the melting of the glacial. At some situation, the condition gets so worsen and river experience an extreme flood condition. On the other hand, the region of many large dams in India are experiencing geological disturbances; Koyana Large Dam in Maharashtra State and Mullaperiyar Large Dam in Kerala State are named to few. The Mullaperiyar Large Dam has crossed the centenary of its age and has failed due to heavy cracks due to geological tremors in the dam structure inspected in the year 2011; thereby causing heavy leakages (Perera et al., 2021). Due to an extreme environmental event that took place recently in the Uttarakhand State of India, where flood wreaks the damage to water storage structure, which was being built on the Dhauliganga river. This happened due to a breach of large glacial causing heavy flood in the river Rishiganga river. One reason to happen this could be attributed to global climatic change and its effect. India’s risk based on climatic change is high with the ranking of seventh most affected country in the world. Owing to this, urgent steps are warranted to protect water storage infrastructures, especially those which are aeging.

Safety of Large Dams in India – a snapshot

Dam Safety organisation was established by the Government of India in the year 1979 and was under the purview of the Central Water Commission of India. The functions of the dam safety organization are to collect the technical information during the inspection visit to the dam by the team of Dam Safety Officers and submit the findings of the condition of the dam and breach of the dam if any (Pant, 1995). The central water commission of India has issued the norms for the inspection and revisit of the status of the dam. As per the issued norms, the inspection of dam need to perform in two stages of which one phase is to get the status of the susceptibility of the dam to failure and being unsafe and the other phase is to get the details of foundation strength, hydrological strength of dam, dam material strength, etc. The overall safety of the dam was measured of two functions and was given as:

$$F = 4 * f_1 * f_2 \qquad \text{Eq. 1}$$

where, f_1 and f_2 are the factors contributing towards the susceptibility of the dam to fail, and potentially unsafe (Pant, 1995)

The failures of many dams, as far as non-structural reasons are a concern, in India are attributed to the flooding too. The dams in the hilly region of India failed by excessive flooding of the rivers. However, the maiden detailed analysis of the failure of dams occurs due to failure of foundation, insufficient spillway, and poor construction in order of their per cent contribution towards the failure (Perlea, 1984).

To fix accountability and bring more clarity in dealing with dam safety in India, the Government of India has enacted Dam Safety Bill 2019. The excerpts of the bill specify functions and responsibilities of the state committee on dam safety, dam safety organization, inspection and surveillance of dams, categorization of dams based on susceptibility to failure and hazardous condition; along with mandatory upkeeping of the record of inspection, maintenance of dams (Lok Sabha, 2019)

CONCLUSION

Though the ageing water storage infrastructure is a global risk since India stands in the third position in the number of large dams out of which many are old and many are ageing, India needs a Strong National Framework to keep the focus on such dams. A strong mechanism of inspection, maintenance supplemented by research on dam safety should be formulated to cope with the emerging risk. It is also required to rethink the policy of construction of large dams as small check dams in larger number could be a solution as the potential created by the construction of large have underutilized, which can be effectively possible through small check dams. A high power monitoring technical team with the latest technological instrumentation needs to monitor glacial regions to avoid accidents like recently happened in India.

REFERENCES

[1] Bid, S., & Siddique, G. (2019). Human risk assessment of Panchet Dam in India using TOPSIS and WASPAS Multi-Criteria Decision-Making (MCDM) methods. Heliyon, 5(6), e01956. https://doi.org/10.1016/j.heliyon.2019.e01956

[2] CWC. (2012). Environmental Evaluation Study of Ramganga Major Irrigation Project, Volume-1, Main Report. Environmental Impact Assessment Directorate CWC. Agricultural Finance Corporation Ltd Hyderabad, February, 312.

[3] Directorate, C. C., Commission, C. W., Development, R., Rejuvenation, G., & Delhi, N. (2017). Monitoring of Glacial Lakes & Water Bodies in the Himalayan Region of Indian River Basins for. 2020.

[4] Lok Sabha. (2019). The Dam Safety Bill , 2019. 2019(190).

[5] Nicobar, A. &. (2018). NATIONAL REGISTER OF LARGE DAMS DAMS OF NATIONAL IMPORTANCE (COMPLETED AND UNDER CONSTRUCTION) STATE-WISE DISTRIBUTION OF LARGE DAMS:- Statewise distribution of Under Construction large dams in India-Pie diagram Project Identification Code (PIC) STATE-WISE. http://www.indiaenvironmentportal.org.in/files/file/NRLD 2018.pdf

[6] Pant, B. (1995). Dam Safety in India: A Review. ISH Journal of Hydraulic Engineering, 1(1), 11–28. https://doi.org/10.1080/09715010.1995.10514567

[7] Perera, D., Smakhtin, V., Williams, S., North, T., & Curry, A. (2021). Ageing Water Storage Infrastructure: An Emerging Global Risk (Issue 11).

[8] Perlea, V. (1984). Scholars ' Mine Lessons from Embankment Dam Accidents . An Introduction. May.

[9] Sataloff, R. T., Johns, M. M., & Kost, K. M. (n.d.). Tailings Dams Risk of Dangerous Occurrences, ISBN 9781626239777

Buckling Analysis of Thin Rectangular Plate

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Abstract - The present research work is concerned with the elastic buckling of uniaxially/ biaxially loaded rectangular plates without hole and with circular and hexagonal holes of different diameters at centre. The rectangular plates are analyzed with eight different boundary conditions, which are SSSS, SSFS, SFSS, SSSF, FSSS, SFFS, FSSF and FFFF. The buckling behavior of rectangular plates is studied using finite element analysis (FEA) with these eight difference boundary conditions, various sizes of plates, with and without holes. This created data base is used for creating artificial neural network. After creating sufficient training and testing, the network is used to solve unknown problems of rectangular plates with various boundary conditions, size of plate and type of holes.

Keywords: Elastic Buckling, Finite Element Analysis, Rectangular Plate, Artificial Neural Network.

Introduction

From the structural design point of view, the elastic stability of thin rectangular plates is one of the most fundamental subjects in many engineering fields. Though considerable amount of work is available on the buckling of isotropic and orthotropic plates of constant length and thickness with width and boundary conditions and subjected to various types of loading, there are limited number of research work on rectangular plates without hole and with circular and hexagonal hole of different diameters at centre.

The availability of various softwares in the field of structural analysis made the design and analysis of rectangular plates a bit easy but using these softwares also requires skill and past experience. It is now possible to calculate the stresses of post-buckling for rectangular plates with any shapes and sizes with or with and type of hole and in different boundary conditions.

This work is concerned with the numerical evaluation of elastic buckling of uniaxially/ biaxially loaded rectangular plates by manipulating width of the plates and type of holes at the centre of the plates keeping the length constant. The study is done using the computer code ANSYS 13.0. This created data base is used for creating artificial neural network. After creating sufficient training and testing, the network is used to solve unknown problems of rectangular plates with various boundary conditions, size of plate and type of holes.

Y. Xiang, C. M. Wang, C. Y. Wang, (2000) [2], reported the elastic buckling of uniaxially as well as biaxially loaded rectangular plates with an internal hinge and at least two opposite sides simply supported while the other two sides may take any combination of boundary conditions.

Y. Xiang, C. M. Wang, et al. (2003) [3] presented the Ritz method for buckling analysis of rectangular plates with an internal line hinge.

Mehmet Fatih Altan (2011) [4], presented the research work of buckling behaviour of rectangular laminated orthotropic plates that have a rectangular hole.

Soumia BENGUEDIAB, Fatima Z. KETTAF, et al. (2017) [5], had presented the behaviour of thin rectangular

Chee-Kiong Chin, Faris G. A. Al-Bermani, et al. (1993) [6] presented a finite element method using thin plate elements.

Harutoshi Kobayashi and Keiichiro Sonoda [7], had developed a power series method with the use of coordinate transformation to solve analytically the buckling problem of uniaxially compressed rectangular plate with linearly tapered thickness.

W. R. Spillers and Robert Levy (1990) [8], this paper extends Keller,s classic solution for the optimal design of columns to the case of plates.

Vasudev R. Upadhey, Chandrashekhar P. Jagtap, et al. (2016) [9] had made an attempt to apply ANN for modelling the initial design of portal rigid steel frame.

Z.-Q. Cheng, J. N. Reddy, et al. (2005) [10] the author has presented the Buckling solution of circular plate with In-plane gravity.

II. DESCRIPTION OF THE PROBLEM

A. Rectangular plate without hole

Under this type of plate, ninety-six problems were analysed with eight different boundary conditions by finite element analysis using ANSYS. The section considered are length 'L' = 1m, thickness 'h' = 0.01m and a changing width 'a' from 0.25m to 1m at difference of 0.25m. All the problems are analysed for uniaxial load in x-direction, y-direction and biaxial load in both x and y direction.

B. Rectangular plate with circular hole

Under this type of plate, ninety-six problems were analysed with eight different boundary conditions by finite element analysis using ANSYS. The section considered are length 'L' = 1m, thickness 'h' = 0.01m and a changing width 'a' from 0.25m to 1m at difference of 0.25m. In addition to this a circular hole is considered with position of the hole kept at the centre of the plate and the diameter is changed as per the change in the width 'a' as (a/5). All the problems are analysed for uniaxial load in x-direction, y-direction and biaxial load in both x and y direction.

C. Rectangular plate with hexagonal hole

Under this type of plate, ninety-six problems were analysed with eight different boundary conditions by finite

element analysis using ANSYS. The section considered are length 'L' = 1m, thickness 'h' = 0.01m and a changing width 'a' from 0.25m to 1m at difference of 0.25m. In addition to this a hexagonal hole is considered with position of the hole kept at the centre of the plate and the side of the hexagon is changed as per the change in the width 'a' as ($0.189\sqrt{a}$). All the problems are analysed for uniaxial load in x-direction, y-direction and biaxial load in both x and y direction

The analysis is carried out using ANSYS 13.0 and the material properties considered for the analysis are Young's modulus E = 210GPa, Poisson's ratio ν = 0.3 and Density = 7850 kg / m3.

III. SYSTEM DEVELOPMENT

It shows that artificial neural network has wide applications in structural analysis and design. The technique of ANN has been employed successfully to the variety of problems ranging from concrete mix design to dynamic analysis of structures. Prior to design any component of the structure through any of the structural engineering software, it is necessary to provide values of cross-section, to check adequacy and economy of the structure. In the present work a model for estimation of initial design parameters i.e. cross-sectional properties of a rectangular plate is developed for different combinations of width, with constant length, thickness and intensity of loading with eight different types of boundary conditions with and without hole. The application of the ANN to develop the initial design of a rectangular plate is reported. For the purpose of developing training data set, computer code is developed for analysis of plane frame using generalized stiffness method using MATLAB.

Artificial Neural Network

A multilayer feed forward neural network consisting number of neurons in each layer namely input, hidden and output layer. The output of any neuron depends on the type of the activation function used. The architectures of neural networks developed in present work are shown in Table 1. These neural networks are trained using the training data set developed as mentioned earlier. The trained network is then presented with unseen problems within the range of training data set and also beyond the range of training data set. The percentage error in predicting values of geometrical properties for unseen problems is calculated.

S. No.	Network Architecture
1	6-7-1
2	6-5-5-1
3	6-7-7-7-7-7-1
4	6-14-14-14-14-14-14-1
5	6-21-21-21-21-21-21-1
6	6-28-28-28-28-28-28-1
7	6-49-49-49-49-49-49-1
8	6-70-70-70-70-70-70-1
9	6-49-49-49-49-49-49-49-49-1
10	6-56-56-56-56-56-56-56-56-1
11	6-63-63-63-63-63-63-63-63-63-63-1

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12	6-70-70-70-70-70-70-70-70-70-70-1
13	6-70-70-70-70-70-70-70-70-70-70-70-1
14	6-77-77-77-77-77-77-77-77-77-77-77-1
15	6-84-84-84-84-84-84-84-84-84-84-84-1

Table 1: Architectures of Neural networks developed in present work

Performance analysis of ANN

This section presents the performance of artificial neural network(s) for training and testing data set with different architectures of network. Initially, the neural network was trained for the developed training data set of known database and the percentage average error was calculated. Then testing database was developed for the unseen problems within the range of trained database and beyond the range of database. The training with seen problem database and testing for unseen problem database was carried out for different network architectures and the percentage average error was calculated for each of the output parameter.

The final network architecture is selected amongst the various network architectures developed on the basis of performance of the network and the percentage average error.

Summary of the Performances of Networks

A summary on number of epochs required for training of network, training time, percentage average error in predicting the geometrical properties of rectangular plates is presented in Table 2 and graphically presented in Graph 1.

IV. CONCLUSION

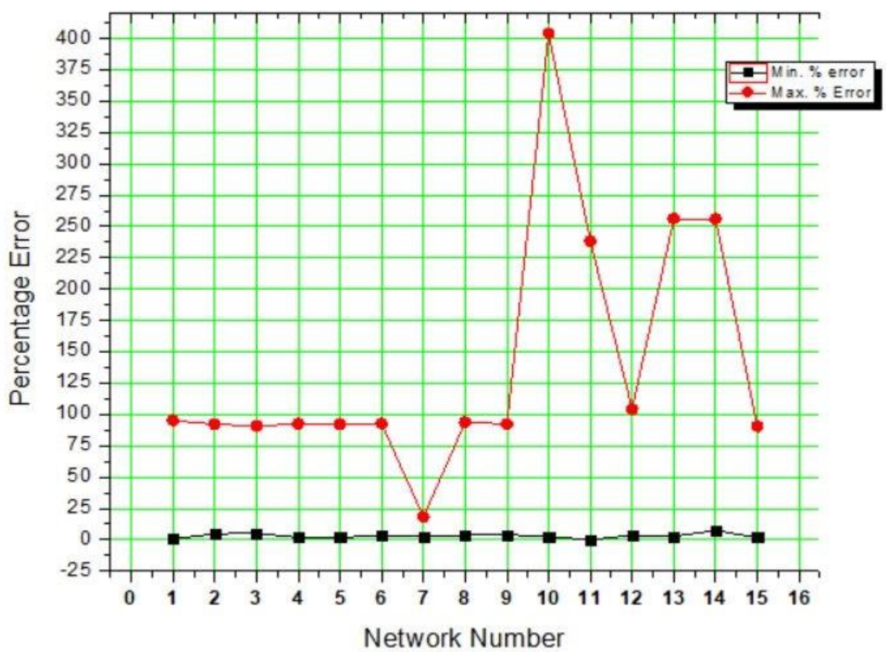
1. A problem is solved from paper "Buckling of rectangular plates with different central holes" by Soumia BENGUEDIAB, Fatima Z. KETTAF, et al. [5] (2017) to validate the analysis done in ANSYS and a error of 2.85% is found in the result which may be due to hear modulus and Thermal expansion coefficient which is not taken into account whereas the author has considered the two.
2. In rectangular plate without hole the buckling factor is increasing when uniaxially loaded with y-direction and biaxially loaded in both x and y directions as the width increases but in case of uniaxially loaded in x-direction buckling factor increases till 0.5m of width and decreases as the increases in width.
3. In rectangular plate with circular hole the buckling factor is increasing when uniaxially loaded with y-direction and biaxially loaded in both x and y directions as the width increases but in case of uniaxially loaded in x-direction buckling factor increases till 0.5m of width and decreases as the increases in width.
4. In rectangular plate with Hexagonal hole the buckling factor is increasing when uniaxially loaded with y-direction and biaxially loaded in both x and y directions as the width increases but in case of uniaxially loaded in x-direction buckling factor increases till 0.5m of width and decreases as the increases in width.
5. Based on the analysis done in ANSYS the ANN is developed. And based on the performance of various trial networks considered in present work, it is observed that the performance of network 7 of the architecture 6-49-49-49-49-49-49-1, is satisfactory. The percentage maximum error is 18.24% and minimum error is 2.39%

Sr. No.	Network Architecture	Training time in Min:Sec	% Min. Avg. Error	% Max. Avg. Error
1	6-7-1	16:09	0.64	95.33
2	6-5-5-1	17:24	4.71	92.18
3	6-7-7-7-7-7-1	21:07	5.31	90.92
4	6-14-14-14-14-14-14-1	19:24	1.79	92.48
5	6-21-21-21-21-21-21-1	12:56	2.09	92.32

ISBN: 978-93-90214-19-8

6	6-28-28-28-28-28-28-1	11:31	3.106	92.66
7	6-49-49-49-49-49-49-1	2:56	2.39	18.24
8	6-70-70-70-70-70-70-1	0:27	3.68	93.96
9	6-49-49-49-49-49-49-49-49-1	0:55	4.04	92.31
10	6-56-56-56-56-56-56-56-56-1	1:38	2.61	404.32
11	6-63-63-63-63-63-63-63-63-63-63-1	1:15	0.167	238.24
12	6-70-70-70-70-70-70-70-70-70-70-1	0:49	3.55	104.26
13	6-70-70-70-70-70-70-70-70-70-70-70-1	1:03	2.66	256.22
14	6-77-77-77-77-77-77-77-77-77-77-77-1	3:41	7.39	256.13
15	6-84-84-84-84-84-84-84-84-84-84-84-1	1:35	1.81	90.41

Table 2 : Summary of the performance network



Graph 1 : Minimum and Maximum Percentage Error in predicted values of geometrical properties of rectangular plates.

ISBN: 978-93-90214-19-8

REFERENCES

[1] Timoshenko, S. P., and Gere, J. M. "Theory of elastic stability" 2nd ed., McGraw-Hill Book Co. Inc., New York, N.Y.,1961.

[2] Y. Xiang, C. M. Wang, C. Y. Wang , "Buckling Of Rectangular Plates With Internal Hinge " International Journal of Structural Stability and Dynamics Vol. 1, No. 2 ,2001

[3] Y. Xiang, M.ASCE; C. M. Wang, M.ASCE; C. Y. Wang; and G. H. Su "Ritz Buckling Analysis Of Rectangular Plates With Internal Hinge" Journal of Engineering Mechanics, Vol. 129, No. 6, June 1, 2003.

[4] Mehmet Fatih Altan "Artificial neural network approach to buckling coefficients of laminated orthographic rectangular plates with a centrally rectangular hole." Scientific Research and Essays, Vol. 8(33) September 4, 2013

[5] Soumia BENGUEDIAB, Fatima Z. KETTAF, Mohamad BENGUEDIAB "Buckling of rectangular plates with different central holes" Mechanics and Mechanical Engineering, Vol. 21, No. 4, 2017.

[6] Chee-Kiong Chin, Faris G. A. Al-Bermani, Sritawat Kitipornchai " Finite element method for buckling analysis of plate structures", Journal of Structural Engineering, Vol. 119, No. 4, April 1993.

[7] Harutoshi Kobayashi, Keiichiro Sonoda, " Buckling of rectangular plates with tapered thickness" Journal of Structural Engineering, Vol. 116, No. 5, May.1990.

[8] W. R. Spillers, Robert Levy, "Optimal design for plate buckling", Journal of Structural Engineering, Vol. 116, No. 3, March 1990.

[9] Vasudev R. Upadhye, Chandrashekhar P. Jagtap, Ajay G. Dahake, " Modelling initial design of steel portal frame using ANN", Journal of Aerospace Engineering & Technology, Vol. 6, Issue. 2.

[10] Z.-Q. Cheng, J. N. Reddy, Y. Xiang, "Buckling of thin circular plate loaded by in-plane gravity", Journal of Applied Mechanics, Vol. 72, March 2005.

P Delta Analysis of Water Tank - A Review

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Abstract - Elevated water tanks are one of the most important lifeline structures in all over the world. The elevated water tanks were collapsed or heavily damaged during the earthquakes because lack of knowledge regarding the proper behavior supporting system of the tank against dynamic effect and also due to improper geometrical selection of staging patters. A structure must be designed to carry every load during its service life, both horizontal and vertical. Among these, lateral loads should be seen with great caution as it tends to more design forces, wind load and seismic loads are the major lateral loads which are imposing on a structure. Owing to the height, stack attracts, a lot of wind forces. And by virtue of its importance, seismic excitation evolution is also a momentous parameter. Seismic effect are evaluated through p delta analysis

P delta is nothing but the secondary moments generated due to the horizontal and vertical forces acting together or structure so there exists a displacement in structure. Analysis carried out for this displacement is considered p delta analysis. The magnitude of the secondary moment is equal to 'p' the axial force in the member time 'delta' its distance one end of the member is offset form the other end. In this paper, the modelling is done for the elevated water tank. The analysis for stability index and P delta effects have been carried out at different staging configurations. The results are then compared to determine whether and when it is necessary to consider P delta effects while designing elevated water tanks.

Keywords: circular tank, tank staging, wind load, seismic load, static analysis, p delta analysis, stability index, etc

Introduction

Liquid storage tanks are unit used mainly by municipalities and industries for storing water, inflammable liquids and other chemicals. The basic aim of elevated water tanks is to make available water supply with sufficient flow, at right time and to wider area of distribution system. A structure should be designed to hold each load throughout its service life, each horizontal and vertical. Among these, lateral loads should be seen with great caution because it tends a lots of design forces. Wind load and seismic loads are the major lateral loads which are magnificent on a structure. Consideration of the height, stack attracts a lot of wind forces. And by virtue of its importance, seismic excitation analysis is additionally a big parameter.

P Delta is nothing but the secondary moments generated due to the horizontal and vertical forces acting along on structure, so there exists a displacement in structure. Analysis distributed for this displacement is considered P Delta Analysis.

LITERATURE REVIEW

The study of papers is done as mentioned below and the particular conclusion or result found by the authors are mentioned itself in Papers summary provide below-

1. R. K. Ingle,,has done research work on **Proportioning of columns for water tank supporting structures.** As per IS: 456 the final design forces shall inclose the effect of deformation (P-DELTA effect), and it is silent almost the calculating this additional forces. As per IS:11682 evaluate the effective length of column and calculate these forces due to its slenderness ratio. According to the ATC code consideration of P Delta effect is necessary if the stability index is more than 0.1 which depend over drift ratio, story height, vertical and horizontal forces. For the study different shape of the column and its arrangement that is radially are considered. And this arrangements plays important role in reducing drift and the stability index.

2. Prashant A Bansode, V. P. Datye , has done research work on **Seismic Analysis of Elevated Water Tank with Different Staging Configuration,** In this paper**,** the

base shear increases as the level of bracing increases because, bracing system put on additional mass to the structure, which results into increase in base shear value Similarly base moment is found to be increased as the level of bracing increases. Marginal displacement and time period of vibration is reduced considerably because, bracing systems increases the stiffness of structure, which reduces the lateral displacement and hence the time period of vibration The present work is carried out to study the behavior of intze type of elevated water tank. It has also chance to study seismic behavior by changing shape of water tank

i.e. Rectangular or Circular water tank. And Model considered in this study is located on hard soil and in zone. It besides be studied behavior of water tank for other type of soil and different seismic zones in India.

3. James Thomas Norris has done work on **Structural Identification of an Elevated Water Tower** and a performance problem in the form of a crack prompted this study of structural identification to characterize the water tank’s behavior and investigate possible reason of the fatigue crack. Analyzing the water tank’s displacement revealed that the wind speeds recorded in the field during this study do not correlate with the variation in displacements observed for the full, half full, and empty data sets: however the variation in displacement does show a strong correlation with the amount of water inside the tank. The investigation of P Delta effects revealed that the water level interior the tank magnifies the initial displacements due to wind and is the source of the variation in displacement observed for the full, half full, and empty data sets.

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4. A. M. Kalani and A. Salpekar has done research work on **A comparative study of different methods of analysis for staging of elevated water tanks** and Regarding different staging configuration, paper gives a comparative study of conventional and matrix methods of analysis for staging of overhead water tanks. By using computer program economic dimensions and design have been carried out. The geometrical dimensions of the system to remains the same except that the number of columns considered as 6, 8 and 10 with inclination of column varies with 0°, 30° and 60°. Here, straight bracings are provided at three levels, which divide the staging in four panels. The stiffness of ring beam connecting top end of columns is considered doubled and bottom ends of the columns are assumed to be clamped with base. These are an approximations considered for the analysis. The maximum bending moment and axial force in columns come in the lowest panel. The combined stresses gives 27.2% higher value in conventional method similar way values of bending moment, torsion moment and shear forces in braces are also higher by 62.1%, 2.7% and 54% respectively. A number of parametric studies, such as the effect in stresses, loading and design of number of braces, column also the batter of columns, have been carried out and it is observed that Axial force in column is not much affected by the batter in the column while stress resultants in braces decrease about 28.8% to 27.6% and horizontal displacement at various braces level decrease about 28% to 37% with increase in the batter of the column.

5. Arbaj Khan Demrot has done research work on **First Order Analysis of Elevated water Tanks during Seismic activity using Staad.pro v8i** and gave results that Overall displacement and deflection is depend on geometry of structural element and displacement increases as move from Zone II to Zone V for all elevated tanks. It is clear that maximum deflection curve felt, in rectangular tank during seismic activity because of its slender structure, Maximum displacement felt in rectangular tank compared to circular and rectangular, hence geometry of tank matters.

6. A.S. Moghadam and A. Aziminejad has done research wok on **Interaction Of**

ISBN: 978-93-90214-19-8

Torsion and P. Delta Effects in tall building, they concluded that **i**n the elastic and inelastic dynamic analyses, they effects of P-Delta sometimes increase the responses and sometimes decrease the responses. The reason is to carry out P- Delta effects in analysis causes change in stiffness matrix of building, thus the natural periods and other dynamic properties of the building will change. providing acceleration response corresponding to the new natural period of building, in response spectrum of the earthquake, is less than acceleration response corresponding to the original natural period, then reduction in building responses for the case with P-Delta can be expected and the "Importance of interaction of torsion and P-Delta effect" mainly depends on the type of lateral load resisting system of building. The results shows that the type of lateral load resisting system plays an important role in degree that torsion modifies the P- Delta effects. It is concluded that the characteristics of lateral load resisting system has far more importance paragon with the number of stories in building.

7. Pushparaj J. Dhawale and Prof. G. N. Narule has done research work on **Analysis Of P-Delta effect on high rise buildings** in this work, P-delta effect is only observed in some of the beams and columns in some load cases. If there load cases are keeper load cases for design of member, then only we can say that it is considerable. This condition is observed in 25 and 30 story buildings and mostly in 30 story building. So we can say this, at least it is necessary to check the results of analysis with and without considering P-delta effect for the buildings with 25 stories (height = 75m).

8. SK. Naseema and G .Shani Priyanka has done research work on **Structural assessment for reinforced concrete elevated overhead water tank** in this study, only frame type staging with a single row of columns placed along the circumference of a circle, are not adequate to support container of elevated water tanks. Another from those, it is required to recognize suitable modified water tank staging system by determining what improvements or added features are necessary for staging part of water tank for better performance during earthquake. Also, alternate or innovative configurations are required to put in practice. The remarkable change in seismic behavior of elevated tanks with consideration of responses like displacement, base shear, base moment, sloshing, torsional vulnerability. Ultimately study discloses the importance of suitable supporting configuration to remain with stands against heavy damage/failure of elevated water tanks during seismic events.

9. Tejas Jain and S. B. Patil has done research work on **P - delta Analysis of RCC Framed High Rise Building Equipped with Shear wall and Damper: An Overview of Experimental and Numerical Study i**n this study, the finite element nonlinear static analysis is used to compare with the currently used linear analysis approach for the lateral displacements of a structure. And Shear wall and damper are effective in reducing the lateral and gravity forces in the building. Location of Shear wall and damper affect the torsional effect of building and economical design will be likely with correct analysis and choice of damper .Location and quantity of dampers can be found out by in depth analysis of building.

10. Jay Lakhanakiya and Prof. Hemal J. Shah has done research work on **A Parametric Study of an Intze Tank Supported On Different Staging's** in this study, Cost of water tank on frame type staging is more than shaft type staging and in increase with change in soil type hard soil to soft soil, also change in Zone 3 to Zone 5. Base shear and overturning moment increase with decrease in bracing spacing. The increment in base shear and overturning moment is very large with change in Zone 3 to Zone 5.

11. Kemal Hacıefendiog˘lu, Murat Emre Kartal and Zeki Karaca has done research work on **The effect of seasonally frozen soil on**

stochastic response of elevated water tank under random excitation in this study, **t**he effect of seasonally frozen soil on dynamic response of the elevated tank during earthquake ground motion. The ground motions due to earthquakes are pendent on many factors such as the source mechanism, travel path and local site conditions. These factors and uncertainties associated with them are difficult to define completely therefore, it is impossible to define a seismic environment to be used in the analysis or design of an engineering system In this paper, the Erzincan Earthquake is used to make of the power spectral density of a particular filtered white noise which is commonly used in earthquake engineering to model the ground acceleration process. Because examining the effects of the seasonally frozen soil on the seismic behavior of the structures during a real earthquake is very difficult, this paper chooses the random earthquake ground motion. The seismic effects on the elevated water tank were emerged as a result of this parametric study.

12. Ankush N. Asati, Dr.Mahendra S.Kadu and Dr. S. R. Asati has done research work **on Seismic Analysis and Optimization of RC Elevated Water Tank Using Various Staging Patterns** In this paper, the seismic behavioral effect of circular elevated water tank is studied for specific capacity of tank for various staging arrangements in plan, difference in number of circumference columns and variation in number of stages in elevation. It is observed those increase in number of columns, does not assure the increase in the improvement of structural responses. Radial arrangement with six staging levels is found to be best for the number of columns used. It is found those eight numbers of columns gives less cost as compared to six, ten and twelve with optimized diameter of 300mm

13. Miss Nikita S. Gholap and Prof. M.N. Shirsath has done research work on **Non Linear Time History Analysis of an Elevated Water Tank**, they concluded that the rectangular water tank without bracing max velocity is 45mm/s. Difference between rectangular water tank without bracing and rectangular water tank with single bracing is 5%, For circular water tank without bracing max velocity is 39mm/s. Difference between circular water tank without bracing and rectangular water tank with single bracing is 8%. Rectangular water tank without bracing maximum deformation is 6.8 mm. Difference between rectangular water tank without bracing and rectangular water tank with single bracing is 30%, For circular water tank without bracing maximum deformation is 4.4 mm. Difference between circular water tank without bracing and circular water tank with single bracing is up to 15-20%

14. Ayazhussain M. Jabar and H. S. Patel has done reseach work on **Seismic Behaviour Of RC Elevated Water Tank Under Different Staging Pattern And Earthquake Characteristics** they concluded that, The critical response occurs in case of full tank and sometime in empty tank. This result may be, due to the fact that the hydrodynamic pressures of container in half-full case as compared with the full filling case are higher. In addition, it can be also assigned to the effect of the frequency content of earthquake records. Frequency content and properties of the earthquake in ranges of natural frequency elevated tank are the most important factors in reduction or intensity of tank responses. Thus, structure responses to each record in addition to the dynamic properties of the structure also depend on the above mentioned properties. Earthquake records with high frequency content cause excitation of responses such as base shear force, overturning moment and roof displacement are compared

15. Tejash Patel, Jignesh Amin, Bhavin Patel has done research work on **Evaluation response reduction factor of RC framed staging elevated water tank using static**

pushover analysis, they concluded that the response reduction factor is considerably affected by the seismic zone and fundamental time period of water tanks. It reduces as the seismic zone increases and increases as the fundamental time period increases. To ensure the consistent level of damaged, values of response reduction factor should be based on both fundamental period of the staging and type of soil. The values of response reduction factor for a given RC framing system should vary between seismic zones. Also the reinforcement detailing requirements should vary with seismic zone. Estimation of response reduction factor with exact analysis will help in an economical design. It is observed that response reduction varies from 2.63 to 4 for tank in full condition in seismic zone V.

SUMMARY OF LITERATURE REVIEW –

After reviewing the papers included in this literature review the overall general summary is given in some important points as mentioned below-

- The investigation of P-Delta effects revealed that the water level inside the tank magnifies the initial displacements due to wind and is the source of the variation in displacement observed for the full, half full, and empty data sets.
- The effects of P-Delta sometimes increase the responses and sometimes decrease the responses. The reason is those implementing P-Delta effects in analysis causes change in stiffness matrix of building, thus the natural periods and other dynamic properties of the building will change, In the elastic or inelastic dynamic analyses.
- P-delta effect calculation is important because while the earthquake occurs, the structure behavior becomes very important and run out to its first order behavior and go to directly to second order, hence it needs to analysis the structure by one of the nonlinear analysis method such as pushover or any other to observe the P-delta effect.
- The increment in base shear and overturning moment is very large with change in hard soil to soft soil.

- Design of water tank by Limit State Method is most economical as the quantity of material required is less as compared to working stress method Water tank is the most important container to store water hence, Crack width calculation of water tank is also necessary.
- The maximum deformations are located along the support-tank interface region. This is related to the change of rigidity and geometry in the interface region.
- The P-delta effect is a second-order effect that occurs on any laterally deformed structure
- Design of water tank by Limit State Method is most economical as the quantity of material required is less as compared to working stress method Water tank is the most important container to store water hence, Crack width calculation of water tank is also necessary.

REFERENCES

[1] R. K. Ingle, “proportioning of columns for water tank supporting structures”, the indian concrete journal, april – 1999, pp. 255-257.

[2] A. M. Kalani and S. A. Salpekar, “A comparative study of different methods of analysis for staging of elevated water tanks”, indian concrete journal, july-august – 1978, pp. 210- 216.

[3] James Thomas Norris, “Structural Identification of an Elevated Water Tower” University of Arkansas, Fayetteville 5-2016

[4] A.S. Moghadam and A. Aziminejad, “Interaction Of Torsion and P. Delta Effects in tall building” 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 799

[5] Arbaj Khan Demrot, ”First Order Analysis of Elevated water Tanks during Seismic activity using Staad.pro v8i” International Research Journal of Engineering and Technology

(IRJET) e-ISSN: 2395-0056Volume: 04 Issue: 09 ISSN: 2395-0072

[6] Pushparaj J. Dhawale and Prof. G. N. Narule, "Analysis Of P-Delta effect on high rise buildings" International Journal of Engineering Research and General Science Volume 4, Issue 4, July-August, 2016 ISSN 2091-2730

[7] SK.Naseema and G.Shani Priyanka, "Structural assessment for reinforced concrete elevated overhead water tank" Volume 2, Issue 12, December-2015, pp. 965-970

[8] Prashant A Bansode V. P. Datye, Seismic Analysis of Elevated Water Tank with Different Staging Configuration Journal of Geotechnical Studies Volume 3 Issue 1

[9] Tejas Jain and S. B. Patil, "P - delta Analysis of RCC Framed High Rise Building Equipped with Shear wall and Damper: An Overview of Experimental and Numerical Study" International Journal of Engineering Technology Science and Research IJETSR ISSN 2394 – 3386 Volume 5

[10] Jay Lakhanakiya and Prof. Hemal J. Shah, "A Parametric Study of an Intze Tank Supported On Different Staging's" IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 09, 2015 | ISSN: 2321-0613

[11] Miss Nikita S. Gholap and Prof. M.N. Shirsath, "Non Linear Time History Analysis of an Elevated Water Tank" IJARST ISSN 2581-9429 International Journal of Advanced Research in Science & Technology (IJARST) Volume 7, Issue 2, July 2020

[12] Kemal Hacıefendiog˘lu, Murat Emre Kartal and Zeki Karaca, "The effect of seasonally frozen soil on stochastic response of elevated water tank under random excitation" Stoch Environ Res Risk Assess (2013) 27:807–818 DOI 10.1007/s00477-012-0609-6Published online: 24 June 2012 Springer-Verlag 2012

[13] Ankush N. Asati, Dr.Mahendra S.Kadu and Dr. S. R. Asati, "Seismic Analysis and Optimization of RC Elevated Water Tank Using Various Staging Patterns" Ankush N. Asati.et al. Int. Journal of Engineering Research and Application ISSN : 2248-9622, Vol. 6, Issue 7, (Part -1) July 2016, pp.20-25

[14] Ayazhussain M. Jabar and H. S. Patel, "Seismic Behaviour Of RC Elevated Water Tank Under Different Staging Pattern And Earthquake Characteristics" International Journal of Advanced Engineering Research and Studies E-ISSN2249– 8974

[15] Tejash patel, Mr. Bhavin Patel and Mrs. Dhara Shah "Formulation of Response Reduction Factor for RCC Framed Staging of Elevated Water Tank using Static Pushover Analysis" Proceedings of the World Congress on Engineering 2010 Vol III WCE 2010, June 30 - July 2, 2010, London, U.K

Review on Design Optimization of Shear Wall in High Rise Building

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Abstract - India's populations are growing rapidly, many people from villages and small town are move towards urban cities for employment and fulfilling their dreams. It tends rapidly growing in urban cities population to fulfill this demands, High Rise building are one of the most good option to fulfill this demand. Structural engineers in the urban cities are seen such problems while having a trouble to design high rise buildings with stiffness irregularities, even when they knew that the buildings are in high risk of failure in under seismic loading. In present scenario tall buildings are becoming more and more slender, as area are limited in cities, lead to the possibility of more sway in comparison with earlier high-rise buildings. By Improving the structural systems of tall buildings can control their dynamic response. By appropriate & proper structural forms such as shear walls, tube structures and improved material properties these problem can be resolve by certain extends. Designers' first choice is Shear wall as it resists the lateral loads such as wind or earthquake load and prevents buildings from damage. Shear wall is slender structure of having a large stiffness value, which resist lateral load and also resist the gravity load. Shear wall gives better performance when it is designed properly and placed at optimum location in the building plan. The structural designers, now days, are practicing to combine the moment resisting framed structure for resisting gravity loads and the RC shear walls for resisting lateral loads in tall building structures. As compared to the structures without shear wall, structures with Shear walls have more strength, stiffness and resist in-plane loads acting along its height also have shown good results. In these paper reviews of literature in the aspect of optimization of shear wall in high rise building is made.c

Keywords: circular tank, tank staging, wind load, seismic load, static analysis, p delta analysis, stability index, etc

INTRODUCTION

The rapid growth of the urban population and high cost of land creates a pressure on available space specially in developing cities. Tall buildings are the today's necessitates today to fulfill these needs. As Designers' first choice is Shear wall as it resists the lateral loads such as wind or earthquake load and prevents buildings from damage. Shear wall is slender structure of having a large stiffness value, which resist lateral load and also resist the gravity load. Wind and seismic loads are the most common loads that shear walls are designed to carry. The distinguishing features are the much higher moment of inertia of the shear wall than a column and the width of the shear wall, which is not negligible in comparison with the span of adjacent beams Shear wall gives better performance when it is designed properly and placed at optimum location in the building plan

LITERATURE REVIEW

The study of papers is done as mentioned below and the particular conclusion or result found by the authors are mentioned itself in Papers summary provide below-

The Author [1] has done research work on Optimization of Location of Shear Wall in Irregular Multi Storey Building. They Optimizes the location of shear based on story drift, story displacement, and torsion of different models On 'H' shape irregular multi storey building and time history method are used. For results they choose compared parameters with H shape plan of without shear wall with varying location of shear wall in Etabs software.

The Author [2] has study done work on Design Optimization and Earthquake Analysis Of Shear Wall in High Rise Building. they consider a model of 15 storey rectangular plan & design as space frame building in zone 3.For analysis Dynamic linear analysis using response spectrum method is used and lateral load analysis is carried out for structure with RC shear walls & steel plates shear wall. For results the earthquake force and bending moment of both cases are compared. They concluded that steel plate shear walls are more resistant to lateral loads in irregular structure and reduces the torsion effect also having a effect behavior of frame under earthquake and reduces the deflection, bending moment in column, shear force, axial force reduction on weight and also quantity of steel. Shear wall with steel plates is economical compare to shear wall with steel plates.

The Author [3] has done research work on Shear Wall Analysis & Design Optimization in High Rise Buildings. They consider a residential building of 19 floors analyzed with and without shear wall. Shear wall were taken at lift, stairs and corners of the building as an L shape. Wall frame structure optimization is part of their work. Dynamic analysis using response spectrum method was used in this project After Optimization of structure the dead weight of building is reduced by 10283.47kN. Which were the good results.

The Author [4] has study has done research work on Shear Wall Analysis and Design Optimization In Case of High Rise Buildings Using Etabs. in this study a 45 storey building with podium upto 4 floor level in zone 3 region by using Etabs software. Optimization techniques are used first by the size of shear wall is same throughout the building and then analysis is done from the result the failed shear wall dimensions are increased to resist the whole structure, by repeating the process optimization was done by trial and error method till the whole structure comes safe.

The Author [5] has work on Effect of Numbers and Positions of Shear Walls on Seismic

Behavior of Multistoried Structure for this study, a G+9 storey building with floor height of 3m situated in zone V. The purpose of this study has been to analyze effect of the numbers and position of the shear walls on the seismic behavior of multi- storied structures. Dynamic analysis has carried out to know the deformations, natural frequencies, and time periods, floor responses displacements. Form the linear dynamic analysis (i.e. Response Spectrum Analysis) it was observed that in the first model of Bare frame there is large deflection and storey drift so it is not considered. A model in which shear wall is completely shows small amount of displacement and storey drift. A model which having shear wall from first storey is also best due to small deflection and storey drift. The model in which shear wall is located at corner position is also good and low cost. As per the analysis Best model in sequence wise are Model of complete shear wall, shear wall from first storey, shear wall at corner position and bare frame.

The Author [6] has work on Effect of Openings of Shear Wall in High Rise Buildings In this work, an analytical parametric study is done for high rise buildings with the shear walls with and without openings for different shapes such as, centrally core (Box type) and at four opposite corners (L-Shape).. The results in terms of lateral displacements and design base shear in shear walls with openings and without openings are compared for the different building models considered in this investigation. It is observed that L-type shear wall shows better performance than Box type shear wall. As number of openings increases base shear decreases and displacement increases with increase in number of openings. Maximum Displacements of buildings with shear walls with and without openings are well within the permissible limits and displacements are less in case of L-type shear wall models compared to Box type shear wall models. The displacements tend to increases with increase in number of openings and number of storey.

The Author [7] has work Solution of Shear Wall Location in Multi-Storey Building the main focus is to determine the solution for shear wall location in multistory building based on its both elastic and elasto-plastic behaviors. A building of fifteen stories located in zone IV. It has been observed that the top deflection was reduced and reached within the permissible deflection after providing the shear wall in any of the 6th & 7th frames and 1st and 12th frames in the shorter direction. It has been also observed that the both bending moment and shear force in the 1st and 12th frame were reduced after providing the shear wall in any of the 6th & 7th frames and 1st and 12th frames in the shorter direction. It has been observed that the in inelastic

ISBN: 978-93-90214-19-8

analysis performance point was small and within the elastic limit. Thus result obtained using elastic analyses are adequate. Hence, it can be said that shear wall can be provided in 6th and 7th frames or 1st and 12th frames in the shorter direction.

The Author [8] has study the Shear wall layout optimization of tall buildings using Quantum Charged System Search In this author used , Quantum Charged System Search (QCSS) algorithm is used as a optimization method and used to improve the convergence capability of the original Charged System Search. The costs of building were taken as objective function. Quantum charged system search is introduced by adding quantum mechanics to charged system search method to increase the efficiency of charged search system so the conventional results increases. By comparing the results between the charged system search to quantum charged system search, quantum charges system search provides better results.

The Author [9] has study on Optimal Seismic Design of Reinforced Concrete Shear Wall- Frame Structures for solving the optimization author used charged system search algorithm as an optimizer for a reinforced concrete dual system. Charged system search (CSS) is an optimization algorithm proposed by kaveh and Talatahari (2010).It is a meta-heuristic algorithm based on laws of Gauss & Coulomb from electrostatics and the Newtonian laws of classic mechanics.

The Author [10] studied on optimal design of tall building with Rectangular shear wall with Rectangular layout For Optimization the conceptual design methodology. A 30 storey tall building with Rectangular shear wall and with rectangular layout was considered investigation was done on six shear wall structural schemes and parameters like lateral stiffness, ratio of inter storey drift, seismic response force, ratio of torsional period to translational period were calculated and conclusion that by comparing the concrete strength and width of shear walls drawn that arrangement of shear walls have influence on material consumption and concrete consumption and steel consumption increase with the increase in aspect ratio of the building.

The Author [11] studied on Significance of Shear Wall in High rise irregular Building .A residential building of G+ 15 irregular structure having the base dimension of plan 24.38m x 25.98m with a stilt floor of height 4m and typical floor of height 3m is considered for the analysis. The superstructure is modeled using standard software ETABS as a space frame. Dynamic linear analysis using response spectrum method is performed by taking zone factor Z=0.1, importance factor I=1 and response reduction factor R=3. It is observed that lateral forces are reducing when the shear walls are added at the appropriate locations of frames having minimum lateral forces. Therefore, it is inferred that shear walls are more resistant to lateral loads in an irregular structure. Also they can be used to reduce the effects of torsion

The Author [12] studied on Seismic Analysis of Multi Storied Building with Shear Walls of Different Shapes. For study a multi storey Building of G+14 and G+29 storey's are analyzed for its storey drift and base shear using ETABS software, under seismic loading with Zone-III & Zone-V. The Shear Wall of U – Shape, W – Shape, H – Section, T – Shape are used in model and compared and concluded On the basis of storey drift and base shear value G+14 building with W and U shaped shear wall is good & H shaped shear wall is good in terms of storey drift .T shaped shear wall is good in terms of base shear. On the basis of storey drift and base shear value G+29 building with W and H shaped shear wall shows good results, T shaped shear wall is good in terms of storey drift and base shear value. There is no change in the better shape of shear wall in both zones.

The Author [13] studied on Optimum Positioning of Shear Walls in Multi storey-Buildings. Objective is to find the Optimum positioning of Shear walls inside the structure. Four different cases of shear wall position i..e Conventional Frame, Shear Walls on Periphery at Corners, Shear Walls on Periphery at Centers, Box-type Shear Wall at the center for a G+10 storey building by keeping the eccentricity zero between mass center and hardness center have been analyzed and designed as a frame system .Concluded that Building with Box-type Shear Wall at the center of the geometry gives best results for high rise buildings.

The Author [14] studied on Optimum Structural Design for High Rise Building. In his study a typical building plan with same loading cases is analyzed for 7 different structural configuration The structural consists of Moment Frame, Moment frame with Shear wall at corners, Moment frame with Core Tubular, Tube in Tube Structure System, Outrigger Structure System, Outrigger with belt truss structure system and compared with the parameters of Base shear, storey response, Time period. Concluded outrigger system will be more efficient amongst the all structural system. As it have lesser displacement and lesser time period.

The Author [15] studied on Design of Multistoried R.C.C. Buildings with and without Shear Walls An earthquake load is applied to a building for G+12, G+25, G+38 located in zone II, zone III, zone IV and zone V for different cases of shear wall position. Lateral displacement and story drift are calculated in all the cases. It was observed that Multistoried R.C.C. Buildings with shear wall is economical as compared to without shear wall. Four different models were studied with different positioning of shear wall in different zones and for various heights to find out the best location of shear wall in buildings. Models are studied and dynamic analysis is performed for G+38 models in all the four zones comparing the lateral displacement, storey drift, concrete quantity required, steel and total cost

required in all the zones. From above analysis, it is observed that in G+12, G+25, G+38 Storey building, constructing building with shear wall at corner location gives minimum drift and minimum displacement. As per analysis, it is concluded that displacement at different level in multistoried building with shear wall is comparatively lesser as compared to R.C.C. building Without Shear Wall. It is concluded that building with shear wall is constructed in lower cost as compared to structure without shear wall.

SUMMARY OF LITERATURE REVIEW

After reviewing the papers included in this literature review the overall general summary is given in some important points as mentioned below-

Steel Plates shear walls requires less thickness as compared to reinforced concrete walls.

The H-shape shear walls configuration is effective during seismic activity among T, U and W shape.

Box type shear wall at the center of the building is found to be efficient

Outrigger structural system found too be efficient in Moment Frame, Moment frame with Shear wall at corners, Moment frame with Core Tubular, Tube in Tube Structure System, Outrigger Structure System, Outrigger with belt truss structure system.

REFERENCES

[1] Saurabh Mishra, V.K. Singh, "Optimization of Location of Shear Wall in Irregular Multi Storey Building" International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE) ISSN: 2456-1290 Volume-ss3, Issue 4, April 2018

[2] L.Rahul, M.Akbar, M.Sriraman, "Design Optimization and Earthquake Analysis Of Shear Wall in High Rise Building", Journal of Xi'an University of Architecture & Technology ISSN No : 1006-7930

[3] Gangisetty Sri Harsha, Dr. H. Sudarsana Rao," Shear Wall Analysis & Design Optimization in High Rise Buildings", International Journal of Engineering and Research Technology. ISSN No : 2277-9655

[4] M.Pavani, G.Nagesh Kumar, Dr. Sandeep Pingale," Shear wall Analysis and design Optimization in case of high rise building using ETABS", International Journal of Scientific & Engineering Research ISSN: 2229-5518, Volume 6, Issue 1, January-2015

[5] S Kasliwal N. A. and Rajguru R. S," Effect of Numbers and Positions of Shear Walls on Seismic Behavior of Multistoried Structure", International Journal of Science, Engineering and Technology Research (2016). Volume 5, Issue 6, ISSN: 2278 – 7798

[6] Vinayak Kulkarni, Swapnil Cholekar, Hemant Sonawadekar, "Effect of Openings of Shear Wall in High Rise Buildings", Int. Journal of Applied Sciences and Engineering Research Issue 4, (2014),ISSN 2277 – 9442

[7] Anshuman S, Dipendu Bhunia and Bhavin Ramjiyani," Solution of Shear Wall Location in

[8] Multi-Storey Building,” International Journal of Civil and Structural Engineering (2011) ISSN 0976 – 4399
[9] Siamak Tala Tahari, Mahdi Rabiei, “Shear wall layout optimization of tall buildings using Quantum Charged System Search”, Front. Struct. Civ. Eng., https://doi.org/10.1007/s11709-020-0660-1
[10] Ali Kaveh and Pooya Zakian,“ Optimal Seismic Design of Reinforced Concrete Shear Wall-Frame Structures”, KSCE Journal of Civil Engineering (2014) 18(7):2181-2190, DOI 10.1007/s12205-014-0640-x,pISSN 1226-7988, eISSN 1976-3808
[11] Men Jinjie, Shi Qingxuan,He Zhijian,"Optimal Design of Tall Residential Building with Shear wall and with Rectangular layout" International Journal of High Rise Buildings Volume 3 Number 4..
[12] Ravikanth Chittiprolu And Ramancharla Pradeep Kumar ,“ International Journal of Education and applied research(2014) Vol. 4, Issue Spl-2, ISSN: 2348-0033
[13] Sanisha Santhosh, Linda Ann Mathew,” seismic analysis of Multi-Storey buildings with shear walls of different shapes”, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 6 Issue 06, June – 2017.
[14] Tarun Magendra, Abhyuday Titiksh and A.A. Qureshi,“ Optimum Positioning of Shear Walls in Multistorey Buildings”, International Journal of Trend in Research and Development, Volume 3(3),ISSN: 2394-9333
[15] Nakul Khanna, Jagdish Chand, “optimum Structural Design for high rise buildings”, International Journal of Innovatation Technology and exploring Engineering.ISSN:2278-3075,Volume-8 issue-8 June,2019
[16] M. S. Aainawala and Dr. P. S. Pajgade “Design of Multistoried R.C.C. Buildings with and without Shear Walls” International Journal of Engineering Sciences & Research Technology (2014) ISSN: 2277-9655.

Effect of Elevated Temperature on Performance of Flat Slab-Column Assembly under Fire Condition – A Review

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Abstract - Flat slab design in contemporary buildings is being preferred due to its various advantages like, reduced floor height, simple formwork, easing installation of services and succinctly cost effectiveness. Although, the flat slab design has benefits, the flat slab structures are considered as vulnerable to punching shear. To overcome the punching shear failure of flat slab at the slab -column junction, several modifications have been carried out such as providing column cap, drop panel and shear reinforcement at slab-column junction. However, the junction area of flat slab-column remains a critical section for the punching shear effect. This punching shear effect gets exaggerated in the elevated temperature condition during fire. In last one and half decade, handful experimental studies have been carried out to understand the behaviour of critical section of flat slab-column junction in higher temperature. Only a limited number of studies have been carried out to validate the effect of fire in flat slab by finite element modelling. This paper aims to review the studies, both experimental and numerical modelling, to understand the wide array of experimental set up configurations, design parameters considered, material and geometrical properties, fire and design load, conclusion and limitations of it

Keywords: Flat slab, elevated temperature, Punching shear, concrete damaged plasticity.

INTRODUCTION

Floor slab without beams i.e. flat slab-column system, In history, in the Johnson-Bovey Building (1905) in Minneapolis, Minnesota, the American engineer C.A.P. Turner employed concrete floor slabs without beams (called flat slabs or flat plates) that used diagonal and orthogonal patterns of reinforcing bars. The developments in advanced construction materials, research methodology, construction equipment, machineries, and computer based computational software has facilitated the analysis of building material and systems in an optimized way. This has led to development of thinner and slender section of the structural members supported by the analysis of the system. Such flat slabs are cost effective, easy to construct without significant change in way of construction and these looks aesthetically appealing. Despite having several advantages, the flat slab is more susceptible to brittle failure under punching effect due to the load it is subjected to. History has witnessed such disastrous failure of flat slab in America, Asia and Europe; some examples are the Skyline Plaza Complex collapse in Virginia (1973), the Harbour Cay building in Florida (1981), the Sampoong Department Store collapse in South Korea (1995) and the Gretzenbach underground parking garage collapse in Switzerland (2004). [1]

Researchers and engineers have made an effort to understand the behavior of punching effect in flat slab. It has been concluded in studies that the concrete strength and reinforcement bars in the critical zone of punching failure have vital role in such punching shear failure. [1], [2]. Number of experimental and analytical studies pertaining to fire effect on RCC members are available, few of them have studied RCC beams, columns and slabs. Only handful of the studies have been carried out in recent years related to fire effect on flat slab-column assembly. For structures other than flat slabs, effect of fire triggers the different mode of failure while in case of flat slab-column assembly, the higher temperature causes the shear failure.[3] The studies related to fire or elevated temperature effect on punching shear effect on flat slab can be divided into four platform, 1. rate and range of temperature of fire, 2. Type of thermal analysis, 3. Effect of various parameter and 4. Behavior of structural members.

For the first one, in most of the studies, the temperature or fire scene has been created with the reference of ISO 834 for fire resistance test (International Standard Organization) and or ASTM E119 (American Society for Testing and Materials' Standard Test Methods for Fire Tests of Building Construction and Materials) [2]-[12] Fig 1. Only in few studies [6], [7] the researchers have used real fire for its effect on slab-column assembly.

This review article presents a state-of-the-art literature review on the effect of fire/high temperature on the flat slab-column assembly. The presented paper also discussed the finite element modelling studies, effect of fire on mechanical properties, elastic properties, concrete damaged plasticity model and critical shear crack theory.

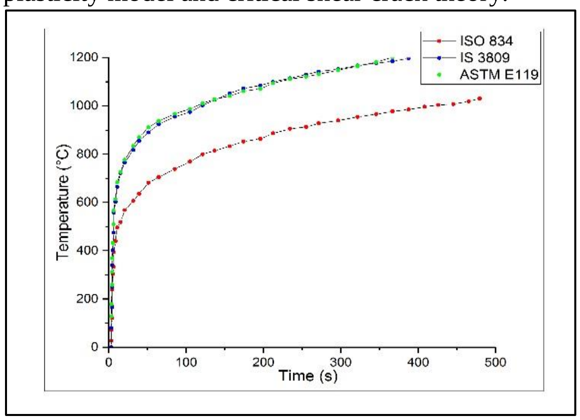

Fig. 1

PUNCHING SHEAR STRENGTH

Punching failure in flat slab can be categorized in two:

1. Flexural Punching
2. Punching Shear

Flexural punching failure is a ductile type and it is the preferred failure over shear punching type failure, since it gives warning before failure. Punching shear type failure is brittle type failure and it leads to sudden collapse with very less cracking and displacement warning. Flexural punching is governed by the amount of reinforcement in flat slab whereas, the shear failure is controlled by tensile and compressive strength of concrete.

The concern with flat slab is its susceptibility to punching shear failure. The punching shear failure can be described as, when the centrally placed column punches through the supporting slab, see Fig. 2 and makes a cone shaped crack in concrete. The behavior of punching sear failure in flat slab is complex mechanism and effect of fire aggravates the punching shear effect more severe.

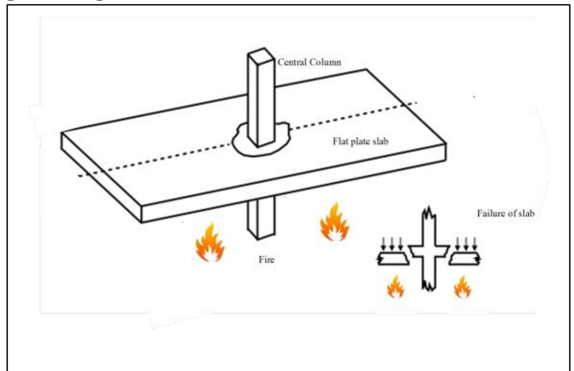

Fig. 2

Numerous studies have been carried out [2] – [7] to investigate the punching shear in slab under fire condition. The model in these studies was very similar, a flat slab with centrally located short column for loading. The model arrangements under studies is shown in Table 3 (table of different model arrangement in ppt). In some models, the slab was studied with the fire on tension side, and compression side. The boundary conditions were varying in the studies, and it has significant effect in the deflection of fire during analysis. Among the various studies, the model studied by Smith et al. [4] – [7], clearly suggests that the deflection of slab is in the direction of source of fire. This behavior is completely opposite to what is anticipated by the researchers. The tension side of the flat slab deflects in concave shape instead of convex shape. Considering the source of fire is at tension side, the results see fig. 3 challenges our understanding that, the thermal gradient developed due to the higher temperature should result in convex shape in the tension side of slab.

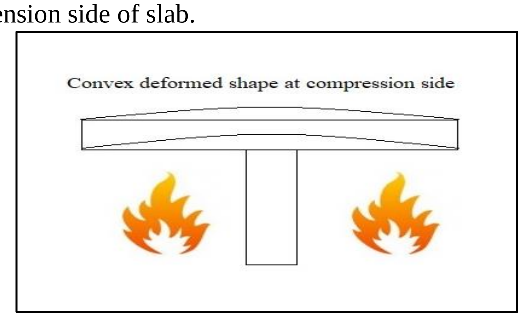

Fig. 3

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CRITICAL SHEAR CRACK THEORY

The zone of punching shear failure is mentioned in various design code. As per ACI 318, IS 456 code, the distance of half the slab depth from the column face and the column is considered as punching shear failure zone. In Eurocode2, the distance is twice the depth of slab from face of column. The researcher [40] has studied the behavior of flat slab, one with shear reinforcements and other without shear reinforcement considering the various parameters like sizes of column, slab thickness.

Critical shear crack theory is a mechanical model that considers the kinematics of cracked section. CSCT is a physical approach which gives consistent and compact design formulations for shear and punching shear in members with and without shear reinforcement. [12 mutton]. The theory assumes that the shear strength depends on the shear crack width and roughness of shear crack. It is based on the shear crack that passes through an inclined concrete compressive strut, which transfers the load on the slab to the column. See fig 4.

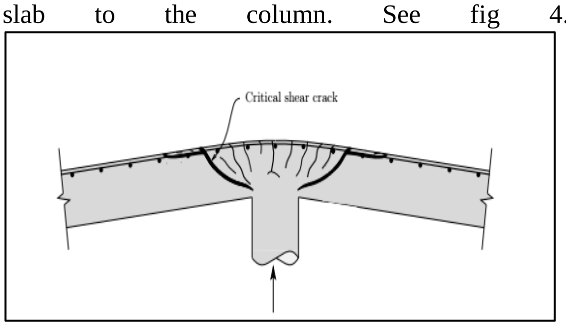


Fig.4

The model is based on kinematic equilibrium equations at failure of the free-body rotation of the slab, relative to the column. These kinematics allow both tensile stresses and aggregate interlock induced stresses to develop along the critical shear crack. The shear strength calculation therefore considers both

the concrete in tension and aggregate interlock contribution, along the critical shear crack failure surface. The punching shear strength is therefore plotted as a function of slab rotation. In two-way spanning slabs, the critical shear crack width is assumed to be proportional to the slab rotation multiplied by the effective depth of the slab. The failure criterion for members without shear reinforcement is calculated with following Equation.

$$\frac{V_R}{b_0 . d_v . \sqrt{f_c}} = \frac{3/4}{1+15 . \frac{\varphi . d}{d_{g_0}+d_g}} \qquad (1)$$

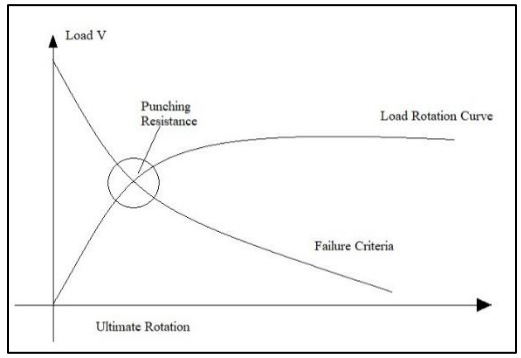


Fig. 5

Table 1. Punching shear analytical models based on critical shear crack theory.

Punching shear empirical equation	Reference
$\nu = \frac{1}{\gamma_c} \frac{2 . \sqrt{f_{ck}}}{3(1+20\frac{\psi d}{16\,mm + d_{agg}})}$	48
$\nu = \frac{3\sqrt{f_c}}{4(1+15\frac{\psi d}{16\,mm + d_{agg}})}$	49
$\nu = \frac{(f_c)^{1/3}}{1+(\frac{\psi d}{4\,mm})^2}$	36

ELEVATED TEMPERATURE

In past decades. Numerous studies have been carried out on the effect of fire on structural elements, however, the focus of these studies were mainly on the flexural response of the reinforced concrete slabs under effect of fire. Very few studies are there which has investigated the shear capacity, punching shear in flat slabs, despite knowing that the flat slab-column junction is prone to failure which requires more consideration. The summarized tables of the studies which has explored punching shear of concrete flat slab subjected fire is tabled below. Table no 3

Researcher [4] tested a set of 14 flat slab samples with central column stubs to study the punching shear behavior at ambient and high temperature corresponding to ISO fire curve (Fig. 3E). Felicetti et al. [3] conducted a set of tests on slab-

ISBN: 978-93-90214-19-8

column connections to study the residual shear capacity after subjecting some of the specimens to high temperature, and reported that reinforced concrete slabs are more shear-sensitive than unreinforced slabs in elevated temperature (Fig. 3). They tested under thermal cycle and a punching load. Recently, Annerel and Taerwe [5] reported an experimental study similar to that conducted by Kordina [4] to study the punching shear behavior of flat slabs under ISO fire (Fig. 3c). However, the results obtained from the study are quite limited. A.

A more recent experimental test was conducted by the authors at Concordia University, Montreal, Canada. Fig. 3 shows the experimental setup, furnace detail and specimens. In this study three pairs (a total of six) slab-column specimens (Fig. 3a) were tested to investigate the punching shear behavior. Of each pair of identical specimens, one was tested in ambient condition and the other was tested at elevated temperature. While all the specimens were identical in size, each pair had different reinforcement ratio. Each slab specimen (Fig. 3b) was of a square shape with 1 m width, 120 mm thickness, and a 150 mm square column stub was located at the center. The dimensions were so chosen that they had a higher possibility of failing in shear, both in ambient and fire conditions. Double layers (top and bottom) of 10 mm diameter reinforcing bars at various spacing were provided in the slab specimens. None of the slab specimens had any shear reinforcements. Figure 4 shows the summary results of experimental studies, and in all cases, it is observed that the punching shear capacity decreases in elevated temperature

CONCRETE'S THERMAL PROPERTIES

Thermal diffusivity is the most important property affecting concrete's thermal behaviour. Mathematically, the thermal diffusivity is affected by its three components under fire conditions: thermal conductivity, thermal capacity, and density. Thermal Conductivity: Thermal conductivity can be defined as concrete's ability to conduct heat. This property is measured by transient or steady-state test methods. Fig. 1 compares several examples [8–11] of concrete's thermal conductivity at different temperatures. The figure shows that concrete's initial thermal-conductivity value under ambient conditions is in the range of approximately 1.33–2.83 W/mK for carbonate aggregate concrete, while the upper limit is slightly lower for siliceous aggregate concrete. These values decrease significantly under high temperatures. Concrete's thermal conductivity loses approximately 90% of its normal value at 1000 C. Many methods have been proposed to obtain the thermal conductivity kc; further information about these methods is detailed in the literature [8–14]

Thermal Capacity: The thermal capacity (ρcp) is the product of the unit weight and the specific heat (cp). The thermal capacity is highly influenced by the moisture content, type and amount of aggregate, and, therefore, by density. Fig. 2 shows the variation of the thermal capacity with temperature from different references [8–11]. It clearly demonstrates that the thermal capacity is almost constant up to 400 C. As thetemperature increases beyond 400 C, an interesting increasing and decreasing variation occurs. However, this variation becomes minimal beyond approximately 800 C. The most important note here, as shown by the comparison between Fig. 2a and b, is that the type of aggregate controls the variations that occur between 600 and 800 C. In conclusion, the aforementioned thermal diffusivity factors are affected by high temperatures. In turn, the thermal diffusivity decreases with a decrease in thermal conductivity and an increase in specific heat.

CONCRETE'S MECHANICAL PROPERTIES

Concrete's mechanical properties play important roles in many of the proposed formulas for predicting the ultimate strength of slabs at elevated temperatures. It is clear from the literature that exposing concrete to fire temperatures leads to a serious deterioration in its mechanical properties. Compressive Strength: Many factors affect the percentage loss in compressive strength due to heating. Among these factors are the water/ cement ratio, aggregate size and type, and test method [11]. However, concrete's initial strength has a trivial effect on the residual-strength percentage [15]. For unstressed samples, concrete loses approximately 18%–20% of its initial strength at 400 C [10,15]. Under the same circumstances, this percentage slightly increases to reach 24% [16]. Moreover, half of the strength is lost between 540 and 590 C for all curves. Fig. 6 shows the degradation of the concrete compressive strength under high-temperature conditions, based on different proposed relationships [8,10,11,15,16]. Elasticity Modulus: The main factors affecting the elasticity modulus are approximately the same as those influencing the compressive strength [17]. However, ACI 216 (Code Requirements for Determining the Fire Resistance of Concrete and Masonry Construction Assemblies) [15] showed that the aggregate type has no significant effect on the elastic-modulus behaviour with temperature. Fig. 4 shows the deterioration of the elasticity modulus of normal concrete, according to tests carried out by Bastami et al. and Li and Purkiss [16,18]. Stress-Strain Relationship: Tests investigating the stress-strain relationship under high temperatures showed both the strength and stiffness decreasing with temperature. However, the ductility increased somewhat between 300 and 800 C [19]. Table 1 includes the latest correlations between the compressive stress and the corresponding strain at elevated temperatures. More stress-strain models can be found in the literature [16,20].

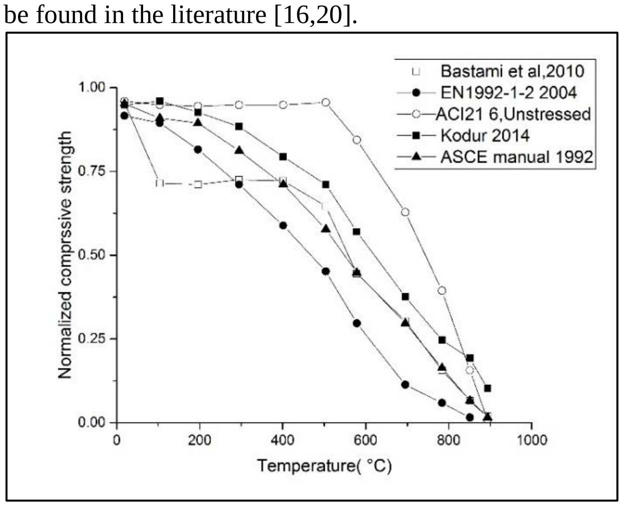


Fig. 6

CONCRETE PLASTICITY PARAMETERS

The concrete '*plasticity'* parameters in Abaqus consist of viscosity *(ν)*, dilation angle *(ψ)*, eccentricity *(ϵ)* , ratio of initial equibiaxial to initial uniaxial compressive yield stress (f_{b0}/f_{c0}) and the ratio between second stress invariant on the tension meridian to the compression meridian*(Kc)* (Dassault Systèmes, 2012). The extension of f_{b0}/f_{c0} and *Kc* parameters to high temperature has beenstudied by Monte, Kalaba and Bamonte (2017) who found that the value of *fb0/fc0* at ambient is in the range of 1.1-1.3, while 2.0-3.0 for temperature 600°C and above. The maximum temperature in slab HU75-08 was below 600°C (Smith, Stratford and Bisby, 2015), so a constant value of 1.16 following the Abaqus default was used for the whole FE analysis. Monte, Kalaba and Bamonte (2017) found that *Kc* was less temperature dependent, with values in the range of 0.6-0.67 for temperatures 20°C to 600°C. The Abaqus default value of *Kc* = 2/3 was used in this analysis.

Eccentricity *(ϵ)* is a plastic flow potential parameter that describe the rate at which the function reach asymptote. For this study, default value of 0.1 was used, indicating that the concrete has a dilation angle which almost similar over a wide range of stress values. The viscosity *(ν)* parameter is for viscoplastic regularization of the concrete constitutive equations, a technique to overcome convergence difficulties (Dassault Systèmes, 2012). Smaller values of ν involve less regularization and could produce more accurate results; however, smaller ν significantly increases the analysis time and is more prone to convergence problems.

Dilation angle defines the concrete dilatancy or a change in concrete volume caused by inelastic strain in Drucker-Prager hyperbolic function, used for concrete plastic flow potential in CDP model (Dassault Systèmes, 2012). The effect of dilation angle ψ, upon the deflection response of concrete flat slabs at ambient temperature was studied by Genikomsou and Polak (2015). They determined a range of ψ = 20° - 42°, and used 40° for their study. Previously reported high-temperature modelling (Al Hamd et al., (2018) and Weerasinghe et al. (2018)) has used an ambient temperature value of ψ from the literature. In this study, several values of dilation angle were examined.

- Compressive constitutive behaviour

The compressive behaviour at elevated temperature can be defined in Abaqus by stress-strain data as a tabular function of an inelastic strain *(εc,in)*, compressive stress *(fc)* and other variables as defined (Dassault Systèmes, 2012). The curve is defined by the concrete compressive strength at elevated temperature $(f_{c,T})$, with the elastic modulus (*Eo,T*) calculated at $fc = 0.4f_{c,T}$.

Concrete compression damage (*dc*) is defined in the descending branch of the curve by *Eq.2*. To avoid potential numerical problems, the descending branch was limited to $f_{c,T}/ 100$

$d_c = 1 - (f_c/f_{cr})$ (2)

Results shows that both compression models produced deflection predictions that are comparable to the experimental test. For the EC2 model, both ψ values of 30º and 35º results were in a good agreement with the test result. For the Anderberg & Thelanderson (A&T) model, ψ of 35º better predicted the response compared to 30º which produced a significant overestimation of the slab deflection. This comparison suggests that the EC2 model is adequate to model the concrete compression behaviour at high temperature for flat slabs (but note that the cooling phase has not been studied here). However, it is not possible to conclude that one compression model is better than the other, as the predictions change with changes in the other parameters (dilation angle in this case) used in the analysis.

- **Tensile Behaviour**

Fig. 7 defines the concrete tensile behaviour at elevated temperature used. Data was provided in a tabular function of concrete cracking strain *(εt,ck)* and tensile stress *(ft)* at the respective temperatures. The peak stress is the tensile strength at elevated temperature (*fc,T*) and the elastic modulus (*Eo,T*) was obtained from the compressive behaviour formulation. The stress data was limited to *ft,T/100* to avoid potential convergence problems. Tensile damage properties were defined in the analysis in a similar manner to the compressive behaviour.

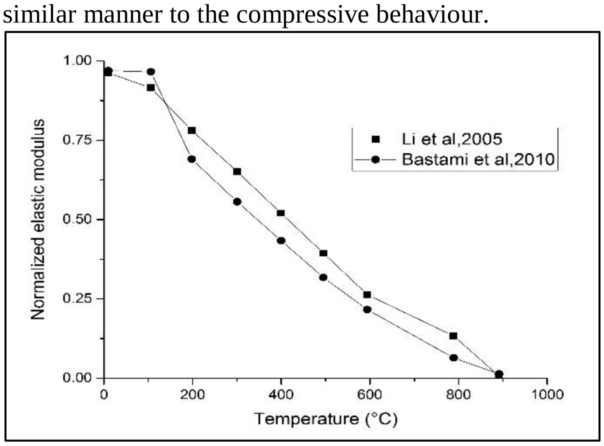


Fig. 7

- **Viscosity**

The viscosity should be as small as possible, but this is not always practical due to computational cost and convergence issues. From this study, a viscosity of 0.0001t is recommended for an analysis at high temperature and could be increase to 0.001t where FE
results still in a good agreement with the test result.

- **Dilation angle:**

Dilation angles of 30° and 35° gave acceptable predictions of the slab deflection response in the FE analysis. However, the "best" dilation angle depends upon the concrete compression model used, ψ = 35° produced the best results with the EC2 model.

- **Concrete compressive model**

Eurocode 2: Part 1-2 model at high temperature produced a comparable result, although transient strain was not explicitly formulated as in the Anderberg
& Thelanderson model. Both models predicted the slab deflection behaviour at high temperature well, but with slightly different value of dilation angle.

- **Concrete tensile model**

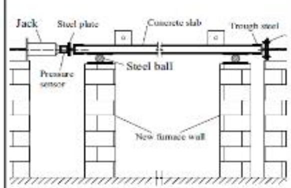
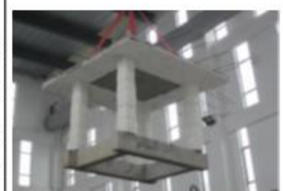
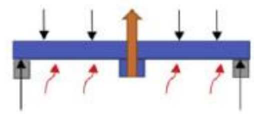
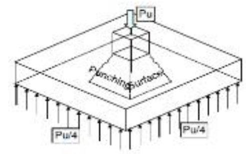
The bilinear tension-softening model from fib Model Code 2010 produced the best slab deflection prediction compared to a linear model or exponential model
by Belarbi and Hsu (1994).

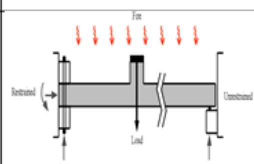
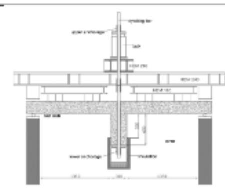
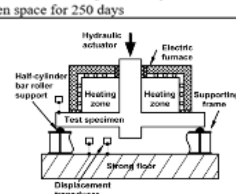
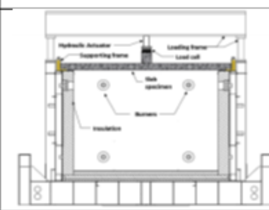
Table 2. Available punching shear tests in elevated temperature.

Reference	Number of slabs	Slab size mm x mm	*h* mm	*c* mm	f_{cm} (MPa)	Elevated Temperature
Present work	3	1000 x 1000	120	150	40	320 °C
Annerel and Taerwe, 2011 [5]	4	3200 x 3500	250	300	28 - 35	ISO fire

Felicetti and Gambarova, 2009 [3]	16	410 circular	75	-	72	105, 250, 400 °C
Kordina, 1997 [4]	14	2500 x 2500	150, 200	250	33 - 51	ISO fire

Table 3. The model arrangements under studies

	Wang et el. (2016)	Ya Wei et. al (2016)	Kordina (1997)	H. Salem et al. (2011)
Slab size and thickness (mm)	3300*3300, T=100 mm	3100*3100, T=95 mm	2500*2500, T = 200, 150	1100*1100, T= 100 mm
Column size *c – column width, d-effective depth	R/f – Fy = 414, 475 MPa	200*200 mm	250*250 mm	150*150 mm
Ambient Concrete Strength	28 MPa	HSSCC 78.9MPa	35-51 Mpa	27 MPa
Steel Strength	Fy = 414, 475 MPa	Fy = 248 MPa	Fy= 504 - 590 MPa	Fy = 270, 410 MPa
Aggregate size and type	Siliceous aggregate			Calcareous aggregate
Heating surface and loading arrangement				
Fire curve	ISO 834 curve	ISO 834 curve	ISO 834 curve	Euro code
Fire duration	180 minutes	120 minutes	120 minutes	60, 120, 180 minutes
Support conditions	Unrestrained and restrained	Restrained	Unrestrained	Unrestrained
Flexural r/f ratio	1.2 %	0.9 to 1.5%	0.56 % and 1.54 %	Compression = 0.5, tension = 1.57 %
Load applied	2 kN/m2	125 kN	Ptest = 70% of ultimate shear strength	200 kN
Measurements	Temperature, Displacement and restrained force	Deflection, temperature	Deflection, temperature	Deflection. Temperature.
Test methodology	fire tests on the reinforced concrete slabs, under combined uni-axial inplane and out-of-plane loading conditions with vertical restraint at four corners of the slabs were conducted.	two-way post-tensioned flat slabs, particularly their deformations and load-carrying mechanisms in fire, and explored the behaviour of post-tensioned high-strength self-compacting concrete flat slabs with unbonded tendons in fire.	Initial load was increased during the first 30 min of fire exposure. Some slabs failed during this period and for others, the load was kept constant after 30 min.	fourteen concentric slab-column specimens was carried out where specimens were tested under concentric punching loads. Twelve specimens have been subjected to fire while two have not and are considered as control specimens. Study parameters were concrete cover, fire duration and cooling method.

	Smith el at. (2015)	Annarel et al. (2013)	Liao et al.(2013)	Weerasinghe et al. (2020)
Slab size and thickness (mm)	1400 *1400 thickness = 50,75,100	3200 *3500 thickness = 250	1220 *1220 , 1800 *1800, Thickness = 120	4750 *3775 mm Thickness 180 mm
Column size *c – column width, d-effective depth	120*120, 100 mm height c/d = 1.4 to 4	300*300, 650 mm height c/d = 1.4	180 *180, 400 mm height c/d = 2	250*250, 400 mm height c/d = 1.7
Ambient Concrete Strength	51 MPa	32 MPa (Requested C25/30)	32 MPa (NSC) and 58 MPa (HSC)	39 MPa
Steel Strength	Fy = 550 Mpa – 571 MPa	Fy = 500 MPa	Fy = 420 MPa	Fy = 550 MPa
Aggregate size and type	Max. size 10 mm Siliceous	Max. size 14 mm Siliceous and calcareous	Siliceous	Siliceous
Curing and conditioning	16 months in a dehumified environment	Cured up to 120 days.	Covered with burlap for 28 days and stored in open space for 250 days	Cured for 28 days
Heating surface and loading arrangement				
Fire curve	Furnace specific. Max. temp. 510 C	ISO 834 fire curve	ASTM E119 curve	ISO 834 fire curve
Fire duration	2 h of heating and cooling down till 150 C in slabs	2 h	Up to 8 hrs	3.5 h and cooling down up to 12 h
Support conditions	Restrained and Unrestrained	Unrestrained.	Unrestrained	Partially restrained
Flexural r/f ratio	0.8% and 1.5%	0.6%	0.92% and 1.43%	0.9%
Load applied	50 kN–250 kN	580 kN–620 kN	116 kN–260 kN	225 kN–275 kN
Measurements	Deflection, In-plane forces, temp	Displacement, temperature	Temperature, Displacement	Temperature, Displacement
Test methodology	Loaded at a displacement rate of 2 mm/ min until the required load had been reached. The load was held constant and slabs were heated. For slabs that didn't fail after 2 h, the applied load was maintained whilst slabs cooled down to 150C.	First, loaded the slab until service load. Load remained constant during heating for 2 h, after which the load was increased up to failure	The load was first applied and maintained for 30–50min until deformation stabilized. Then specimens were heated while maintaining the load until the deformation rate exceeded 7 mm/s or until 8 hrs	The load was first applied at room temperature and maintained until deformation stabilized. Then the specimen was heated while maintaining the load

THERMO-MECHANICAL BEHAVIOUR OF A FLAT PLATE-COLUMN CONNECTION

An extension of the slab-column assembly's mechanical model in normal conditions, to be adopted for fire conditions, is highly questionable. This is attributed to the complexity of the punching behaviour and the nonlinear behaviour of both the heat transfer and material properties' decay. However, the attempt is still interesting. Two major changes have an influence on the total resistance of the slab-column connection behaviour. The first, a reduction in materials' properties, is direct, while the second, increasing the applied load, is indirect. When the slab is heated from one side, it undergoes significant thermal curvatures that result in obvious deflections and rotations.

The carried load is redistributed away to adjacent supports with lower temperatures through an extra hogging moment of the slab over the fixed supports. As a result, the load-equilibrium action will increase the axial load on the column until it reaches the plastic capacity, as illustrated in Fig. 5. This load can reach as high as 40%–50% of the service load [6,21].

The amount of these loads depends on the slab's bending capacity [15,22]. The aforementioned structural behaviour is simultaneous with the changes in the material's thermal and mechanical properties. The degradation in these properties will continue until no more concrete contribution can be expected; hence, the concrete resistance is neglected. Therefore, the slab and columns will gradually lose part of their w(T) depth, depending on the temperature development in the concrete. According to EN 1992-1-2 (Eurocode 2: Design of concrete structures) [10], the norm in determining the fully damaged zone depends on the location of the 500 C isotherm, where the concrete is considered fully damaged, as illustrated in Fig. 6. Fig. 7 shows the temperature profiles from different references [10,21,22]. The slabs were 200-mm thick and exposed to a standard temperature-time fire curve (ISO 834) for 120 min. It can be seen that the temperature development in the layers close to the exposed surface (50 mm from the surface) is approximately the same above 350 C for all curves. However, the temperature profiles near the unexposed surface are slightly different. This is attributed to the different convection boundary conditions there and the different moisture content that can affect the specific heat. Few methods were proposed for the previous two direct and indirect influences. The following sections review the proposed methods for predicting the punching behaviour under high-temperature conditions.

RESULTS:

Despite the differences in the experimental conditions and the results of the reviewed experimental slabs, it is a common conclusion that the fire action decreases the slabs' resistance to punching shear. This decrease is attributed to the decay of the material properties and the extra load that appears from the behaviour of the complete structure under fire conditions. However, the strength-reduction percentage depends on many parameters. Among the effective parameters that were investigated in the presented literature are the slab thickness, the restraint conditions, the reinforcement ratio (both flexural and shear), the preloading, the fire scenario (including exposure direction and duration), and the cooling type.

- Slab thickness effect

The experimental results in the literature showed that thick slabs tended to deform more from the thermal action than the load action [18]. Moreover, the time to failure of thinner slabs was longer than that of thicker slabs [8]. Fig. 8 illustrates the effect of the slab's effective depth on the degree of deterioration of the punching shear strength due to high temperatures, using specimens from different references.

The figure clearly shows that as the slab thickness increases, so does the strength decay. The designations of the used specimens are shown in the figure & listed in Table 3.

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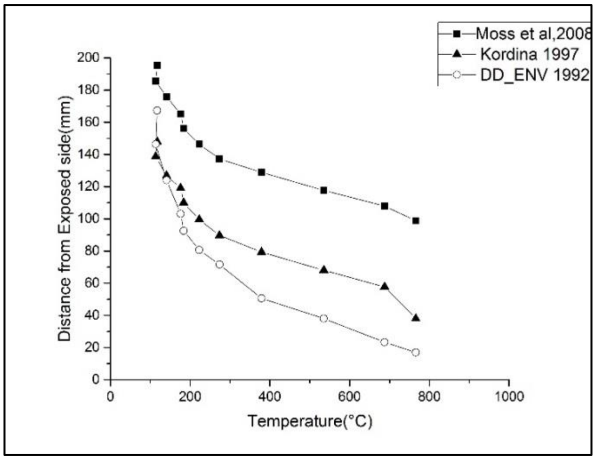

Fig 8

[1] Effect of restraint conditions

Two different edge-restraint conditions can be recognised in Fig. 13: simply supported and fully restrained. The effect of the edge restraint was investigated by Smith et al. [18,23]. They found that the time to failure of the heavy unrestrained reinforced slabs was very short compared with their corresponding restrained ones. However, the percentage loss in punching shear strength was almost the same for both; i.e., about 15% and 17% for the restrained and unrestrained specimens, respectively.

This is mainly because the restraining support adds an extra resistance to the positive moment, which directly affects the ultimate mid-span displacement. However, the benefit from this restraint decreases due to the negative moment arising in the exposed surface and the development of the axial load that was discussed earlier. Fig. 16 shows the effect of the edge restraint on the ultimate mid-span displacement of slabs with the same reinforcement ratio, in both ambient and fire conditions. The effect of the restraint degree is clear in the figure, for 50- and 100- mm slabs. However, for the 75-mm slab, this effect becomes less significant.

[2] Effect of concrete compressive strength

The compressive strength f'c plays a major role in specifying the nominal punching shear strength in ambient conditions. Despite the wide scattering of the results, the influence of f'c (in terms of the square root) is also significant under high temperatures. However, the increase in compressive strength does not necessarily lead to an increase in the residual punching shear strength. The specimens with high compressive strength and a high reinforcement ratio showed higher spalling and lower resistance to fire, compared to those with low compressive strength and low reinforcement ratio [16]. Shows the variation of the normalized punching shear stress with the square root of the compressive strength.

CONCLUSION

Although the flat plate-column connection is a critical region that may cause the collapse of a reinforced-concrete structure under fire conditions, only a few experimental studies have investigated the behaviour of this region when exposed to high temperatures. Studies carried out by Kordina [22], Salem et al. [17], Annerel et al. [7], Liao et al. [16], and Smith et al. [19] were considered among the most significant experimental contributions to understanding the structural behaviour of flat plate-column connections exposed to fire. Bamonte et al.'s [3,6] analytical contribution was also distinguished as an interesting study on the effect of high temperatures on the punching shear of concrete slabs.

From the little available data, it was concluded that high temperatures had two main effects on the exposed structures of concentric flat plate-column joints. The first was due to the direct effect of high temperatures on the material properties; namely, the mechanical and thermal properties decayed dramatically after exposure to fire temperatures. This property degradation might reach 100% at 1000 C. The second effect was indirect, and arose from the unbalanced heating due to the different lengths of the adjacent spans. This effect could add a 50%-higher axial load than in ambient conditions. According to the available literature results, it was concluded that the most effective parameters for punching shear behaviour under high temperature exposure were the exposure temperature and time, the fire scenario, support conditions, exposure surface, nominal strength of concrete, amount of reinforcement, and the preloading and stress history. The experimental results in the literature showed that the residual strength of specimens with high concrete strength and a high reinforcement ratio that were exposed to fire on their compression surface, was more deteriorated by fire than those with a low compressive strength and low reinforcement ratio. On the other hand, the effect of shear reinforcement

 ISBN: 978-93-90214-19-8

on the residual strength of a slab-column assembly after high temperature exposure was minimal.

Another conclusion drawn from the reviewed literature was that sudden cooling after exposure to high temperatures led to more strength deterioration than gradual cooling. Based on the literature review conducted in this paper, further experimental and numerical research works are recommended to increase the available knowledge about the behaviour of flat plate-column assemblies under fire conditions.

Combined fire and imposed loading can adversely affect the structural behavior of concrete flat slab systems. Based on available results from the literature, the following observations are made:

1. The punching shear strength of concrete slabs should be a function of cubic root of *f'c* instead of square root in CSA standard and ACI codes.
2. It is not recommended to concentrate large amount of reinforcement steel in beam-column connection.
3. Some codes (e.g. ACI and CSA) do not account for the influence of the reinforcement ratio on the punching shear capacity and there is an urgency to incorporate this effect in code expression.
4. The flexural reinforcements in concrete flat slabs should not be less than 1% and should rarely exceed 1.5% in real slabs. There is a scope for improvement in this regard.
5. Further experimental studies are needed for concrete flat slab systems with very low reinforcement ratio to develop or modify the design expressions for punching shear at ambient and high temperature.
6. There is a lack of experimental studies mainly due to the difficulties and high cost associated with test setup and experimental facilities in high temperature. Further tests are needed for an enhanced understanding of the punching shear behavior at elevated temperature.
7. The available studies show that the punching shear capacity of concrete flat slabs reduces at elevated temperature. Depending on the reinforcement ratio, the punching shear capacity may reduce by 20-30% when a slab is exposed to elevated temperature reaching close to 3000C for a period of an hour or more.
8. . In the standard fire (e.g. ISO fire) the peak temperature can reach much higher than 3000C, and the punching shear capacity may reduce drastically. Further experimental studies are necessary to quantify the reduction of punching shear strength in that case.
9. Effects of various parameters (e.g. reinforcement ratio, concrete compressive strength) should be investigated in elevated temperature as well as ambient temperature.
10. Further investigation needs to be conducted to simulate more complex scenarios to include spalling and hygrothermal effects
11. The novel Critical shear crack theory as an analytical based method should be explored and updated to account for elevated temperature.

REFERENCES:

[1] P. Olmati, J. Sagaseta, D. Cormie, A.E.K. Jones, "Simplified reliability analysis of punching in reinforced concrete flat slab buildings under accidental actions", Engineering Structures 130 83–98. (2017).

[2] Y. Mirzaei, "Post punching behavior of reinforced slab-column connections", 7th fib PhD Symposium in Stuttgart, (2008).

[3] D.T. Ngo, "Punching shear resistance of high-strength concrete slabs, Electronic journal of structural engineering", Vol. 1, pp. 52-59, (2001).

[4] P. Bamonte, R. Felicetti, P.G. Gambarova,, "Punching Shear in Fire-damaged Reinforced Concrete Slabs", ACI Special

Publication, SP265-16, pp. 345–366, (2009).

[5] N.N. Brushlinsky, M. Ahrens, S.V. Sokolov, P. Wagner, "World Fire Statistics, Center of Fire Statistics of CTIF", International Association of Fire and Rescue Services, No.20, (2015).

[6] C.E. Ospina, G. Birkle, Widianto," Databank of concentric punching shear tests of two-way concrete slabs without shear reinforcement at interior supports", ASCE Struct. Congr. 1814–1832 (2012).

[7] P. Bamonte, R. Felicetti, P.G. Gambarova, "Punching Shear in Fire damaged Reinforced Concrete Slabs, ACI Special Publication", SP265-16,(2009), pp. 345–366.

[8] ISO834-1, "Fire-resistance Tests - Elements of Building Construction - Part 1: General Requirements, International Organization for Standardization", CH-1211 Gen eve 20, Switzerland, (1999). ISO834–1.

[9] ASTM E119, "Standard Test Methods for Fire Tests of Building Construction and Materials", ASTM International, West Conshohocken, PA, (2000). An American National Standard, 21 pages.

[10] P. Bamonte, R. Felicetti, "Fire scenario and structural behavior of underground parking lots exposed to fire", in: F. Wald, P. Kallerova, J. Chlouba (Eds.), In Proceeding of International Conference Applications of Structural Fire Engineering, Session 2 Fire Modeling, Prague, 19-20 February (2009), pp. 60–65.

[11] E. Annerel, et al., "Thermo-mechanical analysis of an underground car park structure exposed to fire", Fire Saf. J. 57 (2013) 96–106.

[12] ASCE, "Structural Fire Protection, ASCE Committee on Fire Protection, Structural Division, American Society of Civil Engineers", New York, (1992). Manual No. 78.

[13] X.F. Hu, T.T. Lie, G.M. Polomark, J.W. MacLaurin, "Thermal Properties of Building Materials at Elevated Temperatures, Institute for Research in Construction", Canada,(1993). Internal Report No. 643, 54 pp.

[14] EN1992-1-2, Eurocode2: "Design of Concrete Structures - Part 1-2: General Rules -Structural Fire Design", CEN, Brussels, (2004).

[15] V. Kodur, "Properties of Concrete at Elevated Temperatures, Hindawi Publishing Corporation", ISRN Civil Engineering, (2014), pp. 1–15.

[16] G.C. Thomas, A.H. Buchanan, C.M. Fleischmann, "Structural fire design: the role of time equivalence, in: Y. Hasemi (Ed.), International Association for Fire Safety Science, 5th International Symposium", Melbourne, (1997), pp. 607–618.

[17] T.Z. Harmathy, "Thermal properties of concrete at elevated temperatures", J. Mater. JMLSA 5 (1) (March 1970) 47–74.

[18] ACI 122R-02, "Guide to Thermal Properties of Concrete and Masonry Systems American Concrete Institute", ACI 122, Farmington Hills, MI, (2002).

[19] ACI216R-89, "Guide for Determining the Fire Endurance of Concrete Elements, American Concrete Institute", ACI 216, Farmington Hills, MI, (1994). Reapproved.

[20] M. Bastami, F. Aslani, E. Omran, "High-temperature mechanical properties of concrete", Int. J. Civ. Eng. 8 (4) (2010) 337–351.

[21] D.J. Naus, "A Compilation of Elevated Temperature Concrete Material Property Data and Information for Use in Assessments of Nuclear Power Plant Reinforced Concrete Structures, Office of Nuclear Regulatory Research, U.S. National Nuclear Regulatory Commission", Washington, DC, (2010). NUREG/CR-7031.

[22] L.Y. Li, J. Purkiss," Stress - strain constitutive equations of concrete material at elevated temperatures", Fire Saf. J. 40 (7) (2005) 669–686.

[23] K. Willam, Y. Xi, K. Lee, B. Kim, "Thermal Response of Reinforced Concrete Structures in Nuclear Power Plants", Department of Civil, Environmental, and

 ISBN: 978-93-90214-19-8

Architectural Engineering, College of Engineering, University of Colorado at Boulder, (2009). SESM No. 02.

[24] D.J. Naus, "The Effect of Elevated Temperature on Concrete Materials and Structures- a Literature Review", Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC, (2006). NUREG/CR-6900.

[25] P.J. Moss, R.P. Dhakal, G. Wang, A.H. Buchanan, "The fire behavior of multi-bay, two-way reinforced concrete slabs", Eng. Struct. 30 (2008) 3566–3573.Fig. 17. Effect of compressive strength on the slabs' ultimate strength with different pre-loadings. F.H. Arna'ot et al. Fire Safety Journal 93 (2017) 39–52.

A Review on Prediction of Sewage Treatment Plant Performance Using Artificial Neural Network

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Abstract - Wastewater issues and water related health hazards are a cause of concern in India. Almost 80% of the water supplied for domestic use, comes back as wastewater. Sewage Treatment Plants (STPs) have been constructed to reduce the degradation of water quality of the receiving water bodies by reducing the total pollution load and to ensure a healthy environment. Poor design, operation or maintenance of wastewater treatment systems causes wastewater discharge with high levels of pollutants that creates major environmental problems, when such waste water is discharged into surface water or on land. The performance of a wastewater treatment plant is based on the analysis of major water quality parameters, such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Settle able Solids, Total Dissolved Solids (TDS), Nutrients (N&P) and Oil grease. In this paper, a literature review has been undertaken to study the application of Artificial Neural Networks in analysis of these parameters for evaluation of performance efficiency of a wastewater treatment plant.

Keywords: Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Waste water treatment, Artificial neural network

INTRODUCTION

The term waste material generally encompasses liquids and waterborne solids from residential, agricultural or business functions likewise as different waters that are employed in the activities of man, whose quality has been compromised, and that area unit discharged into a sewage works. Since many years the word "sewage" has been used and typically refers to waters that contain solely hygienic waste. Technically, "sewage" means that any voidance that goes into a drain. Domestic waste material may be a stream that seems muddy or opaque and contains solids in suspension. It's gray in color once young, and includes a musty scent. Domestic waste material contains all varieties of liquid materials out there in different quantities, like feculent solids, little bit of fruit, gasoline, trash, pulp, rags, wood, plastics and different materials disposed of in a very community's way of life. In such conditions, the color of the liquid will slowly amendment from gray to black, because of organic chemistry changes caused by bacterium.

Fig no :-1 Sewage treatment plant

As shown in fig. 1, the individual treatment strategic area units are typically classified as: Physical unit, operations Chemical unit processes, Biological unit processes.

The performance of a wastewater treatment plant is based on the analysis of major water quality parameters, such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Settleable Solids, Total Dissolved Solids (TDS), Nutrients (N&P) and Oil grease. Traditionally many statistical techniques are used for prediction of performance of a sewage treatment plant. Recently Artificial Neural networks has been used for performance prediction.

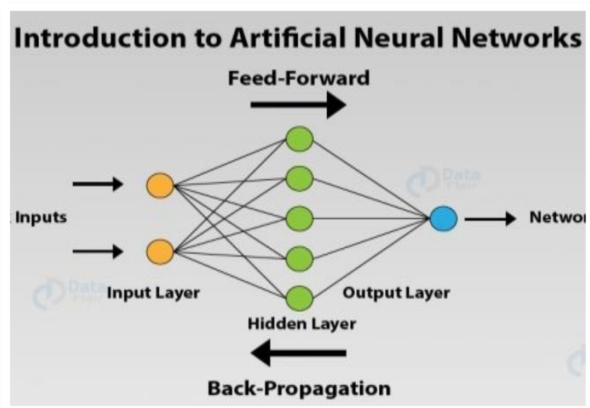

Fig 2. Structure of Artificial Neural Network

Artificial neural network consists of artificial neurons or processing elements and is organized in three interconnected layers: input, hidden that may include more than one layer, and output. Artificial Neural Network (ANN) strategies are applied to varied areas of environmental problems like waste material treatment. The waste material treatment method is sort of complicated. But the developments in intelligent strategies create them attainable to use in complicated systems modeling. The predictive models presented for the estimation of BOD at the outlet are calculated form ANN [1]. It is often used for higher prediction of the method performance due to their high accuracy, adequacy and quite promising applications in engineering [2,3,4]. The ANN based models gives satisfactory results. One of the most common training algorithms feed forward back propagation algorithm is used by Tumer et al [7]. Total suspended solid (TSS) is a sign of plant performance. A straightforward prediction models supported neural network for toxic shock was incontestable [8]. The results of modelling study expressed high coefficient of correlation between the measured and foretold output variables reaching up to 0.9[4].

Background study

The discharge of waste material to environments caused adverse condition and this semiconductor diode to the event of intensive ways of biodegradable pollution treatment. deposit and chemical precipitation were one amongst the primary processes used for waste material treatment. In 1865, early experiments on biological science of sludge digestion were conducted in European country. In 1868, early experiments on intermittent filtration of waste material were conducted, whereas in 1870 early experiments on intermittent sand filtration were created in European country. In 1876, 1st tank was developed within the us. In 1882, 1st experiments on aeration occurred in European country. us was the primary to use bar racks in 1884. In us 1st chemical precipitation treatment plant was put in in 1887. In 1889, filtration in touch beds was tried at the Lawrence Experiment station, Massachusetts. In 1891, the tactic of sludge digestion in lagoons was developed in Federal Republic of Germany. In 1895, gas gas was collected from the septic tanks and used for plant lighting in European country. the primary rotary sprinklers for rotary filters were developed in 1898. the primary grit chambers were developed within the us in 1904. The offensive character of the sludge made by deposit semiconductor diode to the utilization of septic tanks within which the solids were rendered additional or less inoffensive, however difficulties of assorted types semiconductor diode to the final adaption of Travis two-storey tank in European country in 1904 and therefore the Imhoff tank that was proprietary in Federal Republic of Germany in 1904. The chlorination of waste material for medical care was incontestible by Phelps within the us, in 1906. the primary municipal installation of a trickling filter was created in us in 1908 and at constant time laws of medical care were developed by Chick in us. In us, the primary Imhoff tanks were created in 1911. at the same time, in 1911 separate sludge digestion was adopted in us to differentiate it from the two-storey tank method. In 1912-13 aeration of waste material in tanks containing slate was dispensed at Lawrence Experiment station. In 1914, experiments were conducted by Arden and Lockett that semiconductor diode to the event of the activated sludge method, whereby a high degree of purification is achieved. the method was 1st applied in an exceedingly municipal plant for treating biodegradable pollution at San Marces, Tex in 1916. In 1925, contact aerators were developed by Buswell in us. The ever-changing characteristics of waste material, thanks to discharge the various} contaminants area unit accountable for the many changes that area unit happening nowadays within the waste material

 ISBN: 978-93-90214-19-8

treatment. waste material or biodegradable pollution treatment is one such various, whereby several processes area unit designed and operated so as to mimic the natural treatment processes to scale back waste product load to grade that nature will handle. during this regard, special attention is important to assess the environmental impacts of existing waste material treatment facilities.

Literature review

Oliveira et al (2002) has developed an estimation model that can be provide accurate predictions of the output stream of biological wastewater treatment plant. The average hydraulic residence time in the aerated lagoons has been used to establish a data input/output relationship. The original database, obtained from the plant control system and from the laboratory was found to be much unusable information that must be eliminated, so the two-year daily record was reduced to 71. The best results were obtained for the ANN composed of five neurons in the hidden layer using the Delta-Bar-Delta (DBD) technique, which had a correlation index of 0.60 for the validation set of predicted and observed BOD’s. In order to improve this result and to prune the ANN structure, input variables were preprocessed, using the Principal component Analysis (PCA) technique.

Nasr et al (2012) has used the default Levenberg–Marquardt algorithm for training. In this study STP is a sequencing batch reactor (SBR) system which is located in Alexandria EGYPT with a design capacity of 50,000 m^3 /day and achieves a secondary treatment to meet the Egyptian effluent-standards for the treated domestic sewage. The results of this study indicated high correlation coefficient (R-value) between the measured and predicted output variables, reaching up to 0.9.

In this work, the researcher Husain et al (2012) has characterized the domestic and industrial wastewater by high pollutants such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), Ammonia Nitrogen (NH3-N), Phosphorus, heavy metals and pathogens. According to the researcher, removing pollutants that are incorporated in wastewater is the major objective of any WWTP in the world. The basic design of the BTR is shown in figure 3.

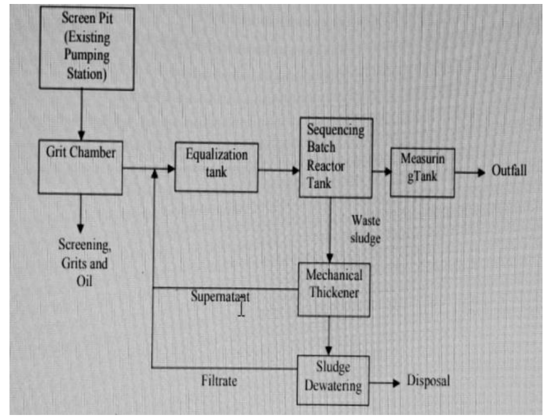

Fig. 3 The design of water treatment plant at BTR

In this paper by Kundu et al (2014), have taken special efforts on ANN. The training of ANN model was carried out by presenting the complete input data set to the network and continued till the average MSE was minimized.

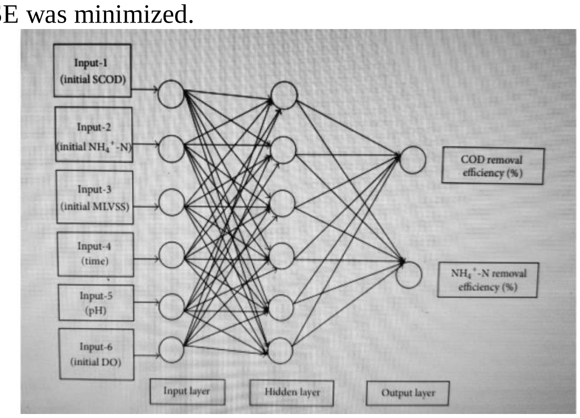

Fig 4. Architecture of ANN Model

Testing of the trained network was carried out by presenting the set of test data and then comparing the output of the network with the actual values of the output. The performance of formulated ANN model was measured by several statistical parameters, such as coefficient of determination (R), MSE, and RMSE MSE Value of 0.15584 is much higher for 2 neurons in one hidden Layer. With the increase of neuron numbers in the hidden Layer, there was a gradual decrease in MSE values attaining A minimum value of 0.00575 with 18 neurons in one hidden Layer. With the further increase of hidden neurons, there was A sharp increase in MSE values.

In the work done by TÜMER et al (2015), the neural network model was created in MATLAB. The

Network properties are Network inputs: flow rate, pH, COD, BOD, Temperature and TSS, Network outputs: TSS, Network type: Feed-Forward Back-Propagation, Training function: TRAINLM, Adaption learning function: LEARNGDM. Performance function: MSE, Number of hidden layers: 1,2,3 used respectively, Input Layer Transfer function: logsig, purelin and tansig, Output Layer Transfer function: purelin. The authors have also vastly covered the detailed information about wastewater treatment plant, 1. Preliminary Treatment Units: Wastewater inlet structure coarse grid, entrance pump station, Coarse and fine grids, Aeration Grid and Grease Removal Unit, Preliminary settling pool, 2. Biological Treatment Units: Aeration Tanks/ Activated Sludge Reactors (Bardenpho Process), Secondary Sedimentation Tanks, 3. Sludge Treatment, Biogas Production and Energy Recovery Units: Sludge Dewatering Tanks, 4. Mesophilic Anaerobic Sludge Digesters: Biogas Storage Tanks, Heating plant and energy recycling unit, Sludge Dehydration Plant (Decanter Centrifuge) 5. Disinfection: Open Channel UV disinfection system, the ANN can predict the plant performance with correlation coefficient (R) between the observed and predicted output variable reached up to 0.96

In this research by Djeddou et al (2015), an Artificial Neural Networks based approach for modeling and predicting wastewater treatment plant reliability using Activated sludge (AS) was proposed. Using the presented approach, an artificial neural networks model for AS was constructed using data relating to influent and effluent concentrations. Operational control of a biological WWTP is often a complicated task. Modeling a WWTP is considered a difficult task due to complexity of the treatment processes. All ANN models were built on MATLAB.

In the research paper by Choksi, Sheth, Mehta (2015), the authors have evaluated the efficiency of each parameter and overall efficiency of sewage treatment plant during the summer and winter season.

The researchers have studied the importance of each parameter in wastewater engineering. And also evaluated the removal efficiency of BOD and TSS of sewage treatment plant in summer season and evaluated the removal efficiency of BOD and TSS of sewage treatment plant in winter season. The samples were collected from the Anjana Sewage treatment plant located at Surat. The treated and non-treated samples have been collected six times per month from august to march and have been checked in the laboratory every two days in the weekends.

Puspalatha et.al (2016) reviewed on design approach for sewage treatment plant. A case study of srikakulam greater municipality. The present study involves the analysis of parameters like BOD, raw sewage, effluent. The construction of sewage treatment plant will prevent the direct disposal of sewage in Nagasaki river and the use of treated water will reduce the surface water and contaminated ground water.

Patil et.al. (2016) studied on design of sewage treatment plant for Dhule city. Some treatment units are designed like screens, grit chamber, storage tank, settling tank, aeration tank and skimming tank. The effluent can also be used for artificial recharge of ground water, flushing, foam control, fire protection, lawn sprinkling.

Conclusion

The efficiency of Sewage treatment plant is necessary for the working of function of various units of STP. It was found by all the researchers that the design as well as the performance of sewage treatment plant study is effective with the help of ANN technique. Artificial Neural Network is a new upcoming technique efficiently used by many researchers for the performance prediction of sewage treatment plant.

References

1. K. P. Oliveira - Esquerre, M. Mori, and R.E Bruns ,"stimulation of an industrial wastewater treatment plant using artificial neural network and principal components analysis," Brazilian journal of chemical engineering. Vol.1 y (4), pp. 365-370, 2002.
2. M.S Nasr, M. A Maustaya , H.A Seif and G.EI Kobrosy ,"Application of ANN for the prediction of EL- AGAMY WWTP Performanc - EGYPT ," Alexandria engineering journal Vol, 51(7) , pp. 37 - 43 2012.

3. Mohammed S. Jami, Iman Hussain, "Multiple Input ANN model for the prediction of WWTP performance Australian journal of basic and applied science vol 6 (y) pp. 62 - 69. 2012.
4. P. Kundu, A. Debsarkar, S. Mukherjee, and S. Kumar, "Artificial neural network modelling in biological removal of organic carbon and nitrogen for the treatment of slaughterhouse wastewater in a batch reactor," Environmental technology, vol 35 (10), pp. 1296 - 1306, 2014.
5. Abdullah Erdgl Tumer, Serpil ENE BALI, "Artificial neural network model for wastewater treatment plant of konya, "International Journal of intelligent system and application in engineering, (250), pp .131 – 135, 2015.
6. Messaoud, Djeddou, Hellal , Aouatef , Imed, Loukam, "wastewater treatment plant performance modelling using artificial neural networks," water science and technology, pp. 53 – 65, 2015.
7. Kavita N. Choksi, Margi A Sheth, Darshan Mehta,"To evaluate the performance of sewage treatment plant : A case study ," International research journal engineering of technology vol . 2 pp. 1076 - 1080, 2015.
8. Puspalatha and Kalpana, "Design approach for sewage treatment plant: A case study of Srikakulam greater municipality", India, volume no.12. 2016.
9. Prof. Pramod Sambhaji Patil, Shaikh Hujefa, Deo prasad, "Design of sewage treatment plant for Dhule city" volume no.5, pp:353-355. 2016.

Applications of Remote Sensing and Geographical Information System for Reservoir Catchment Management (A Case Study For Kanva Reservoir Catchment, Ramanagaram District, Karnataka, India)

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Abstract - Water is the basis of life on earth. It is the main component of the environment and an essential element for human life. Water is also fundamental for sustaining a high quality of life and for economic and social development. But the essential resource is under threat. Increasing demand and untreated waste water discharge aggravates the stress on water bodies. It now appears that one of the main factors limiting the future economic and human development will undoubtedly be water.

Lakes and reservoirs are vital parts of fresh water ecosystems of any country. The water quality of a lake is a reflection of the condition of its catchment. The intensive agricultural practices and landuse changes due to residential development in the catchment has reduced the inflow into these reservoirs. The lakes and reservoirs, all over the country without exception, are in varying degrees of environmental degradation. The degradation is due to encroachments, eutrophication and siltation. There has been a quantum jump in population during the last century without corresponding expansion of civic facilities resulting in deterioration of lakes and reservoirs, especially in urban and semi-urban areas becoming sinks for the contaminants. The degradation of reservoir and lake catchments due to deforestation, stone quarrying, sand mining, extensive agricultural use, consequent erosion and increased silt flows have vitiated the quality of water stored in the reservoirs.

The study area viz., Kanva reservoir catchment has an areal extent of 340 sq.km.It is encompassed by E Longitude 77º07'15"- 77º18'10" and N Latitude 12º38'58"- 12º59'11". The paper discusses the integrated catchment studies for better management of reservoir. The physico-chemical and bacteriological analyses of surface and ground water samples in the reservoir and its catchment reveals that water is polluted at certain locations. Water samples were analyzed for irrigation requirements and USSL diagram, Piper trilinear diagram were plotted for classification of water samples and spatial distribution of water quality parameters is carried out using GIS Arc-Info software. Remote sensing data are used for mapping land use and land cover, physical and chemical analyses of soil samples in the catchment area reveals low fertility index in certain locations, Morphometric analyses were carried out for the entire catchment to determine the linear, areal and relief aspects of the catchment. Double- ring infiltrometer is used for field infiltration measurements. Evapotranspiration studies were carried out using Penmen-Monteth method, soil erosion potential zone mapping is done using Universal Soil Loss Equation (USLE) which shows severe erosion at certain locations in the catchment area. Estimation of runoff is carried out using SCS-Curve number method using GIS. The Integrated Reservoir Management approach will be an effective tool for sustainable management of lakes and reservoirs. The paper also discusses various management plans for effective management of reservoirs through integrated reservoir catchment management approach.

Keywords: Reservoir catchment, Water and soil quality, Soil erosion, Remote sensing and GIS

INTRODUCTION

Many of the present cities previously emerged as settlements, along water bodies. The relation between settlements and water is unique and important. The paradigm here is water is considered a source, which sustains life, nurtures occupations and supports religious beliefs. The water bodies in an urban set up include the rivers, streams, nalas, lakes, tanks, wells, etc.

Lakes are vital parts of fresh water ecosystems of any country. A fresh water lake when maintained free from pollution can offer many beneficial uses in an urban area. Urban lakes more commonly act as thermal cooling, reaction centres and de-stressing points in the highly-stressed urban life nowadays due to pressure from activities like urbanization, industrialization, as well as the asthetical beauty of the water body and the commercial value of the surrounding area is improved. Lakes provide life to various forms of aqui flora and fauna livelihood for fishermen community, food for the local populace, pollution sink ground water recharge leading to rise in the water table and as flood mitigators. The urban population can free themselves from the polluted urban air and find solace in the cool air by the lake side and relax in recreational activities such as swimming, boating, fishing and strolling along the lake shores.

The ill-effects of negating water have caused urban ecological imbalance, pollution, unhygienic conditions, and floods during rains. The trends of development and increased land demands have caused encroachment of tank beds, sewage disposal into tanks and nalas. As a result of increased population growth, intensified use of surface waters exploitation of adjacent lands and properties, and other human pressures, inland lakes increasingly are being threatened.

Restoration means returning an ecosystem to a close approxiamation of its condition prior to disturbance. This ensures that the ecosystem structure and function are recreated or restored, and that natural dynamic ecosystem processes operate effectively again. The physical, chemical and biological integrity of surface water is achieved by- Correcting nonpoint source pollution problems; Restoration of all types of habitats with priority to the habitats of endangered species. The most wide spread problems facing lakes in bangalore are sewage from domestic sector, effluents from industrial sector (point sources), and agricultural nonpoint runoff of silt and associated nutrients and pesticides. This has led to eutrophication, due to excessive inputs of nutrients and organic matter. Hydrologic and physical changes and siltation from catchment activities have resulted in special decline. Lakes are sinks for incoming contaminants that recycle and maintained that impaired conditions. There is an urgent need to take up the restoration of lakes.

Lake revival/rejuvenation/restoration is a much talked about subject in the recent years. Lakes are being destroyed by putting the lake land for different uses in its entirety are the peripheral area encroached upon or the inlet valleys changed/diverted/destroyed and if the lake land is untouched it is used as a dumping yard for the solid wastes/waste water (sewage, sullage)/effluent from the urban developments in the catchments of the water body.
The above factors hassled to either loss of the lake in its entirety or reduction in the area of the water body or the lake being deprived of aquatic life and choked with aquatic weeds leading to depletion of dissolved oxygen in lake water and release of obnoxious gases due to anaerobic reaction in the lake water. Mosquitoes breeding leads to various vector diseases on the surrounding areas of the lake.
Due to inadequate infrastructure facilities for waste disposal in the urban areas the urban lakes get polluted due to its natural topography and invariable at as collection points for the waste from the haphazard urban settlements. As a result of this and a number of other compounding factors most of the urban lakes area getting degraded beyond the point of recovery. Encroachments, accumulation of silt, weed infestation, discharge of domestic sewage, industrial effluents are the main causes for degradations of these lakes. Declining water quality, nuisance algae blooms, excessive weed growth, deteriorating fisheries, sediment infilling, eutrophication, contamination, bund erosion, water-use conflicts, impaired scenic qualities and upward appreciation of property values around the lake due to rapid urbanization are common problems being experienced by lake over seers as a result of human activities. These and other critical problems are avoidable. The lakes are prone to the causes of deterioration and degradation.

STUDY AREA

The Kanva River along with its subsidiary drainage form one of the tributary systems of the Shimsha river in the Karnataka part of Cauvery Basin. The Kanva river system, draining parts of Magadi, Ramnagaram, Chanapatana taluks of Ramanagaram district and Kanakapura taluk of Ramanagaram district bound between E Longitude 77º7'15''-

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77º18'10" and N Latitude 12º28'55"- 12º59'11" is covered in parts of survey of India topographic maps 57H/1, H/2, H/3 and H/5 on 1: 50,000 Scale. The area forms a part of semi arid tract and falls under the agro-climatic environs of 'Eastern Dry Zone' of Karnataka. Out of the total extent of 356.14 Sq-km area of the Kanva river watershed, considering the ideal representation of the geological, geomorphological and agro-climatic set up an extent of 356Sq-km bound between E Longitude 77º7'15"- 77º18'10" and N Latitude 12º38'58"- 12º 59 '11" forming the catchment and command area of Kanva reservoir was selected for study.

Kanva reservoir is constructed across Kanva river, Cauvery basin, under subseries of Shimsha river. It is located in Kannamangala village, Channapatna taluk, of Ramanagaram district. It is constructed in the year 1940. The catchment area is 340.4 Sq km and irrigable command area is 2076 ha. The water spread area of the reservoir is 488.0 ha. The length of right bank canal is 25 km and left bank canal is 15km. Right bank canal has a discharge capacity of 3.07 m³/sec and left bank canal has a discharge capacity of 1.86 m³/sec. the area under irrigation of left bank canal is 771.0 ha and the right bank canal is 1305 ha.

Fig 1.Kanva Reservoir Command Area

Fig 2 Kanva Catchment area

Geology of the study area

The western part of the Kanva reservoir catchment, forms a part of the older Gneissic complex and rest of the catchment and command area of the Kanva reservoir i.e. to the east of the older gneissic belt forms a part of younger Granites which are otherwise referred to as 'Closepet Granites'.

The 'Closepet Granite' belt is represented by both pink and grey granites, indicating that it is not a single mass of granite. This younger granite suite is well represented by coarse grained porphyritic granite with huge phenocrysts of potash feldspars. The granites in the area are more seen as high hills. The porphyritic granites are oval to circular plutons.

Geomorphology and Drainage Features

A major part of the Kanva river watershed in the study area forms a rugged hilly tract of northerly extending Closepet granite belt. The area is dotted with isolated mounds, hillocks and hill clusters. The hills in general have attained heights of 900 to 975m above MSL. Maximum 1054m above MSL is the height of the hill located in the Siddadevara Betta state forest. The intermountane valleys are dotted with rock knobs and sheet rocks.

The river Kanva originates about 5km NW of Magadi town at an altitude of 870m above MSL (E Longitude77º10' and N Latitude 12º58'). It follows a linear south easterly flow for about 21 km, abruptly attains SSW trend (about 3 km east of Jalamangala) and thus flows for about 4 km and flows furtherly south-westerly for about 9km upto the village Kanva in which place a reservoir has been constructed across its flow (E Longitude77º11'15" and N Latitude 12º43'12"). Further down, at a place called Abbur, it attains a southerly course and drains into the river Shimsha at about a Km SW of Savandipura.(E Longitude77º 10' and N Latitude 12º 28' 55") at 592m above MSL. Thus, the Kanva River with nearly 65 km flow course has a topographic fall of 278m. This amounts to an average fall of 4.28m per km of flow course. Similarly, from the point of origin of the Kanva River up to the Kanva reservoir i.e. over a course of 34 km, there has been a fall of 170m and these amounts to a fall of 5m per km of flow course.The important tributaries of the Kanva River in the area are 'Bhargavathi Hole' at the left bank and 'Sital tore Nala' at the right bank.

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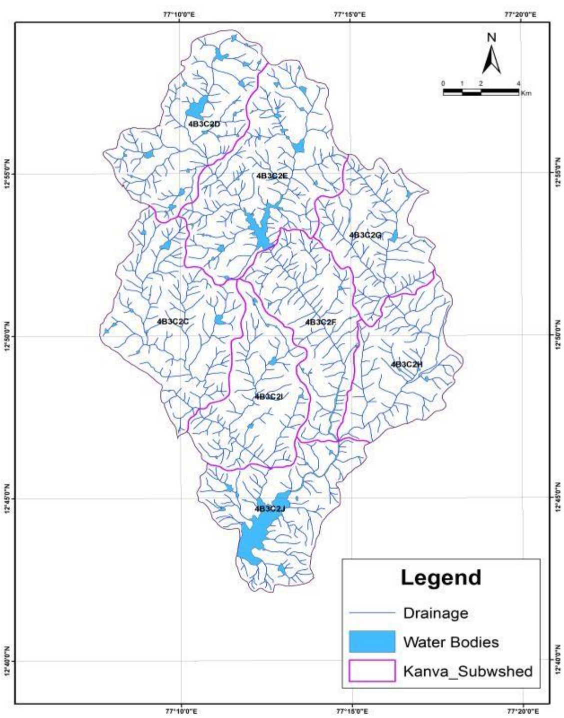
Geomorphologically, the eastern part of the area forming the granitic terrain symbolizes shallow to partially weathered pediplain. But, the gneissic rock formations in the west, constituting mostly a pediplain terrain are moderately weathered. The pediment, dissected pediment, pediment-inselberg complex, denudational hills, resistant hills are characteristic of the granitic terrain. The valley fills are restricted to a narrow strip on either bank of the Kanva River more so along when it had attained the South- easterly linear course. But, the extent of the valley fill is considerably more and distinct when the drainage attained a South-Westerly trend. The linear ridges are mainly of the dykes that have intruded into the parent rocks.

Drainage map of Kanva Reservoir Catchment area



METHODOLOGY

The physico-chemical and bacteriological analyses of surface and ground water samples in the reservoir and its catchment reveals that water is polluted at certain locations. Water samples were analyzed for irrigation requirements and USSL diagram, Piper trilinear diagram were plotted for classification of water samples and spatial distribution of water quality parameters is carried out using GIS Arc-Info software. Remote sensing data are used for mapping land use and land cover, physical and chemical analyses of soil samples in the catchment area reveals low fertility index in certain locations, Morphometric analyses were carried out for the entire catchment to determine the linear, areal and relief aspects of the catchment. Double- ring infiltrometer is used for field infiltration measurements. Evapotranspiration studies were carried out using Penmen-Monteth method, soil erosion potential zone mapping is done using Universal Soil Loss Equation (USLE) which shows severe erosion at certain locations in the catchment area.

Estimation of runoff is carried out using SCS-Curve number method using GIS.

RESULTS AND DISCUSSION

Morphometric characteristics of the catchment area

The morphometric analysis of drainage basin and its stream channel system can better be achived through the measurements of linear, areal relief aspects of channel network and contributing ground slopes.Drainage network map and slope maps were prepared using Survey of India (SoI) toposheets on 1:50,000 scale. The various morphometric parameters were presented in table1 and 2.

Table 1.Catchment Morphometric Characteristics

Stream order	1	2	3	4
No. of Segments Nu	567	276	26	2
Total Length (Km) Lu	358.43	147.79	56.49	26.42
Bifurcation ratio (Rb)	-	2.05	10.22	13.50
Mean Length (Km)Msm	0.63	0.54	2.09	13.21
Cumulative Length(Km) ∑Lu	567	843	870	872
Stream Length Ratio RL	-	1.18	0.26	0.16
Drainage Density (Km/Sq.km) Dd	1.6			

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The elongation ratio of the catchment is 0.5 which is associated with strong relief and steep ground slopes. The length of overland flow is 0.312km/km2 which indicates surface runoff entering the stream will be quicker. The value of drainage density is 1.6 which indicates the catchment area is coarse textured. The value of constant of channel maintenance is 0.41km2/km which confirms the presence of structurally controlled stream system within the catchment.

Table2.Drainage characteristics of the catchment

Sl No	Catchment Parameters	Units	Values
1	Catchment Area (A)	Sq.km	356.14
2	Perimeter of the Catchment (P)	km	86.37
3	Catchment Stream Highest Order		4
4	Maximum Length of catchment	km	31.80
5	Maximum width of Catchment	km	19.5
6	Cumulative Stream segment		872
7	Cumulative stream length	Km	589.13
9	Drainage density	km/Sq.km	1.66
8	Length of overland flow	km/ Sq.km	0.312
10	Constant of channel maintenance	Sq.km/km	0.41
11	Stream frequency	No/Sq.km	1.70
12	Bifurcation ratio		8.59
13	Length ratio		1.86
14	Form factor		0.61
15	Shape factor		2.84
16	Circularity ratio		0.77
17	Elongation ratio		0.50
18	Compactness coefficient		1.30
19	Total Catchment relief	Km	0.42
20	Relative Relief		0.01
21	Ruggedness Number		1.04

Water and Soil quality aspects.

Ground water samples were collected from catchment and command area of the reservoirand surface water were collected from lakes and the reservoir durning september2020. Physico-chemical and biological analysis was carried out for the watersamples collectedfrom various locations using standard procedures recommended by APHA-1994. The location of various sampling points is as shown in the Fig4. The results can be used for classifying water for irrigation requirements and drinking water standards.

The results of the Physico-chemical and bacteriological analysis of water samples is presented in the Table 2.The water is classified based on hardness by Sawer and McCarthy and the classification is presented in the Table 1. The suitability of ground water for irrigation purposes depends upon its mineral constituents.The general criteria for judging the quality are (i)Total salt concentration as measured by electrical cponductivity (ii)Relative proportion of sodium to other principal cations as expressed by SAR,(iii) Soluble sodium percentage.(iv)Residual sodium carbonate (v) Residual sodium bi carbonate.

Wilcox classified groundwater for irrigation purposes based on percent sodium and Electrical conductivity.Eaton recommended the concentration of residual sodium carbonate to determine the suitability of water for irrigation purposes. The US Salinity Laboratory of Department of agriculture adopted certain techniqes based on which the suitability of water for agriculture is explained.Classification of irrigation water based on sodium water content is mapped.

$$\%Na = (Na^{+} \times 100/ (Ca^{+2} + Mg^{+2} + Na^{+} + K^{+})$$

Where the quantities of Ca, Mg, Na and K are expressed in milliequivalents per litre(epm).

Table 3 Soluble sodium percentage classification

Sodium%	Water class	Water samples
< 20	Excellent	K-W13, K-W15
20-40	Good	K-W1,K-W2,K-W5,K-W6, K-W7, K-W9,K-W10, K-W16,K-W19,K-W22,
40-60	Permissible	K-W3, K-W4, K-W8, K-W-12, K-W14, K-W17, K-W20, K-W21, K-W23,K-W24
>60	Not suitable	K-W11, K-W18

 ISBN: 978-93-90214-19-8

Table 4: Classification of water based on RSC(Residual sodium carbonate)

RSC(epm)	Remarks on water quality	Water samples
<1.25	Good	All the samples belongs to this category
1.25-2.5	Moderate	Nil
>2.5	Unsuitable	Nil

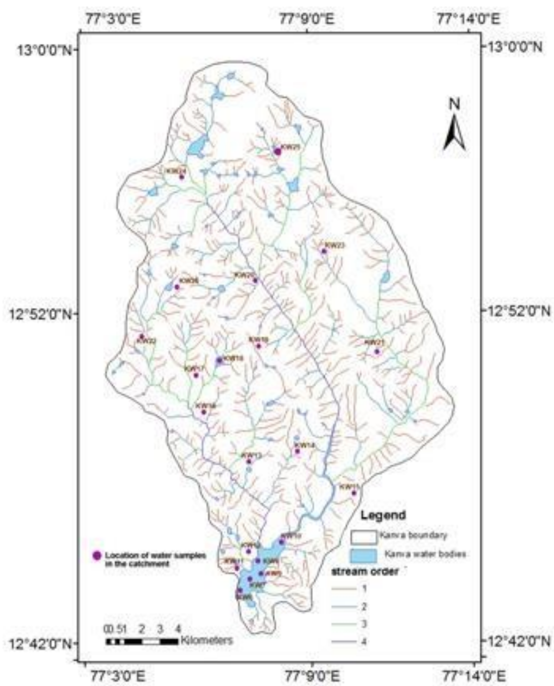

Fig 4:Location of Water sampling points in the Kanva reservoir catchment

The classification of watersamples with respect to soluble sodium percent is shown in Table 3. In water having high concentrations of bicarbonate,there is a tendency for calcium and magnesium to precipitate as water in the soil becomes more concentrated. As a result, the relative proportion of sodium in the water is increased in the form of sodium carbonate RSC is calculated using the following equation.

RSC= (HCO3- + CO3-2) – (Ca^{+2} +Mg^{+2})

Where all the ions are expressed in epm

According to the US Department of Agriculture, water having more than 2.5epm of RSC is not suitable for irrigation purpose. RSC classification of Water samples of the study area is npresented in the Table-4

A better measure of the sodium hazard for irrigation water is Sodium adsorption ratio(SAR) .which is used to express reactions with the soil. SAR is computed as

SAR= Na^{+}/[(Ca^{+2}+Mg^{+2})/2]½

Where all ionic concentrations are expressed in epm

The graphical representation of results of SAR and Specific conductance for all the water samples as per USSL diagram is done. The classification of water samples from the study area with respect to SAR is represented in Table 5. The total concentration of soluble salts (salinity hazard) in irrigation water can be expressed in terms of specific conductance. Classification of water based on salinity hazard is presented in Table 6.

Table 5: Classification of water for sodium hazard based on USSL Classification

Sodium Hazard class	SAR	Remarks on water quality	Water samples
S1	10	Excellent	Range 0.92 to 7.71 All water samples belongs to this category
S2	10-18	Good	NIL
S3	18-26	Moderate	NIL
S4	>26	Unsuitable	NIL

Table6: Classification of water for salinity hazard

Salinity hazard class	EC (micro-mohs/cm)	Remark on water quality	Water samples
C1	100- 250	Excellent	NIL
C2	250-750	Good	257.5 -645.0 9 samples
C3	750- 2250	Moderately good	761.2-1774.1 11 samples
C4	2250-6000	Unsuitable	2398.1-3125.4 4 samples
C5	>6000	Highly Unsuitable	NIL

 ISBN: 978-93-90214-19-8

Table 7 Water quality based on irrigation water requirements in the catchment and command area.

Sample no	Sodium Adsorption Ratio	Ca+Mg meq/l	Soluble sodium percentag e (SSP) %	Magnesiu m Hazard meq/l	Chloride s meq/l	Residual Sodium carbonate RSC in meq/l	Permeability Index	Kelley’s Ratio
K-W1	1.386	14.397	36.56	0.453	3.72	-4.35	36.37	0.256
K-W2	2.179	9.832	32.97	0.338	5.68	-3.82	49.76	0.491
K-W3	3.180	6.141	52.09	0.375	7.512	-1.106	69.59	1.087
K-W4	4.067	13.82	43.61	0.361	8.288	-4.847	55.83	0.773
K-W5	2.413	15.566	30.91	0.382	10.878	-8.543	42.08	0.432
K-W6	1.121	2.938	31.61	0.310	1.445	0.05	71.54	0.462
K-W7	2.409	2.537	28.88	0.402	3.171	-1.201	73.69	1.069
K-W8	1.448	2.033	41.79	0.336	1.035	0.02	82.63	0.718
K-W9	1.598	2.204	30.73	0.458	0.979	0.31	81.73	0.761
K-W10	1.520	1.981	29.45	0.481	1.119	0.060	83.61	0.760
K-W11	7.705	11.138	62.01	0.396	10.849	0.024	73.40	1.63
K-W12	3.440	10.946	42.29	0.350	5.96	-3.277	56.90	0.732
K-W13	0.920	7.725	18.98	0.523	2.022	-2.05	43.96	0.234
K-W14	3.445	10.834	55.54	0.662	13.275	-0.268	68.88	1.249
K-W15	1.286	16.678	18.21	0.406	5.340	-4.077	35.62	0.222
K-W16	1.424	15.087	20.59	0.402	6.979	-5.286	37.06	0.259
K-W17	2.108	3.531	44.24	0.453	1.213	0.679	76.29	0.793
K-W18	2.833	1.325	63.50	0.416	1.703	-0.02	95.18	1.740
K-W19	1.571	2.949	27.13	0.412	0.674	-0.169	68.37	0.372
K-W20	1.981	2.203	48.56	0.365	1.040	0.03	83.24	0.944
K-W21	2.088	2.500	48.28	0.279	1.117	0.06	80.99	0.916
K-W22	1.531	10.427	24.58	0.443	4.661	-4.063	43.23	0.335
K-W23	3.806	8.840	42.33	0.561	4.812	-0.992	60.60	0.734
K-W24	2.810	3.822	50.42	0.355	2.846	0.02	75.79	1.017

Table8 Results of Chemical analysis of soil samples in the Study area.

H-High, L-Low, M-Medium, S-Sufficient, D-Difficient

Sample no	Name of the village	pH	EC mmh os/c m	Organic Carbon %	Available Phosphorus (P) Kg/acre	Av. Potash (K) Kg/acr e	Available Micro nutrients			
							Zn ppm	Cu ppm	Mn ppm	Fe ppm
K-S1	Doddaganganavadi	7.7	0.1	0.41 L	4 L	166 H	1.12 S	1.5 S	35.5 S	24.9 S
K-S2	Akur	6.4	0.03	0.35 L	5 L	72 M	2.33 S	1.3 S	36.6 S	36.2 S
K-S3	Belagavadi	4.6	0.09	0.28 L	9 L	60 L	1.3 S	1.7 S	31.0 S	37.4 S
K-S4	Gejagerekuppe	7.7	0.09	0.78 L	8 L	200 H	4.34 S	4.5 S	41.9 S	41.0 S
K-S5	Banjarahatti	5.9	0.02	0.59 L	6 L	128 H	0.89 S	0.7 S	30.0 S	32.8 S

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K-S6	Dasavara	6.1	0.05	0.66M	9L	142H	0.74D	1.1S	42.1S	45.9S
K-S7	Kundurdoddi	6.5	0.03	0.34L	6L	116M	0.21D	1.9S	33.9S	23.9S
K-S8	Torehosur	6.7	0.02	0.35L	8L	132H	1.29S	2.7S	42.4S	29.5S
K-S9	Patlu	7.1	0.01	0.41L	5L	156H	0.72D	0.96S	52.4S	33.9S
K-S10	Thirumaladoddi	6.8	0.03	0.28L	9L	163H	0.39D	1.7S	37.5S	45.6S
K-S11	Kanva village	6.3	0.02	0.31L	7L	190H	0.54D	1.0S	25.6S	19.5S
K-S12	Maregowdanadoddi	6.3	0.01	0.27L	9L	94M	0.94D	1.2S	40.5S	44.2S
K-S13	Tavarekere	6.1	0.02	0.34L	8L	88M	0.76D	1.7S	30.3S	54.1S
K-S14	Aralakuppe	6.8	0.03	0.48L	5LL	121H	0.69D	1.1S	39.4S	52.4S
K-S15	Dandigepura	6.4	0.04	0.39L	6L	330H	0.55D	1.2S	33.6S	21.8S
K-S16	Jalamangala	7.2	0.04	0.51M	12M	207H	2.18S	2.0S	40.5S	33.8S

The Physical and chemical analysis of soil samples were carried out at 16 locations as shown in Table8.The chemical analysis of water samples reveals that soil is deficient in Zn at various locations and having low Percentage carbon and Available phosphorous.

Field Infiltration measurements

Infiltration characteristics of soil are very important for scientists, engineers and planners. Hydrologists mostly need infiltration data for the estimation of peak rates and volumes of runoff in the planning of dams, culverts and bridges etc. It is also useful for minimizing the erosional hazards. Most important use of infiltration is to the agriculturists and ecologists who are concerned with the availability of soil moisture in the root zone of crops and plants. Hortons equation is used to characterize the infiltration rate in the catchment area of the present study. Double Ring Infiltrometer is used for Infiltration measurements. The Hortons equation is as shown below.

$$fp=fc+(fo-fc)e^{-kt}$$

Where fo is the infiltration rate at the beginning of the storm, fc is the ultimate or final infiltration capacity attained when the soil profile becomes saturated, fp is the infiltration capacity at time't' and k is an empirical constant. Horton suggested the above equation for separating rainfall into rainfall excess and infiltration. This equation is applicable only when the rainfall rate exceeds fp. The constant k depends upon both the basin and rainfall characteristics; fo depends upon initial moisture condition of the basin and fc varies depending upon the season.

Table 9 Field Infiltration studies

Sl no	Location	Horton's equation
1	Jalamangala	$F = 17.21 + 6.97e^{-11.0085t}$
2	Akkur	$F = 19.43 + 7.22e^{-5.1581t}$
3	Maregowdana doddi	$F = 21.844 + 15.54\ e^{-10.9016t}$
4	Satanur	$F = 7.3655 + 1.20\ e^{-7.3088t}$

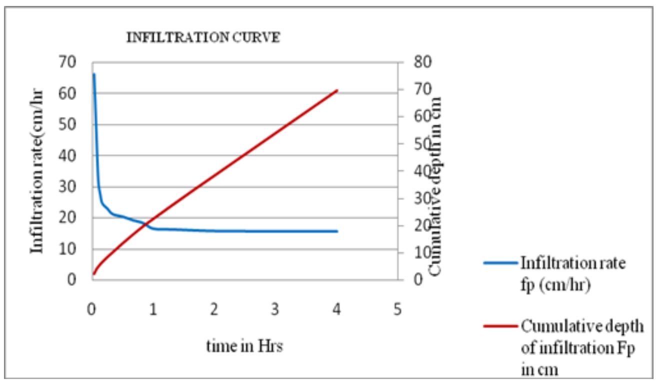

Fig 7 Infiltration Rate curve for Maregodanadoddi Evapotranspiration measurement

Evapotranspiration (ET) includes water that is needed for both evaporation and transpiration.ET is defined by the US Geological Survey as the water lost to the atmosphere from the ground surface, evaporation from the capillary fringe of the groundwater table, and the transpiration of groundwater by plants whose roots tap the capillary fringe of the groundwatertable. Evapotranspiration is considered to be one of the key elements in the

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water cycle that needs to be quantified to achieve better water management. In the present study FAO-56 Penman-Monteith method is used for the computation of Reference evapotranspiration.The max and minimum values of monthly evapotranspiration is shown for 3 locations for past 5years is shown in table 10. The FAO-56 Penman-Monteith Equation for computation of reference evapotranspiration is shown below.

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)}$$

Table 10 Monthly ETOvalues in mm/month for various locations

Location	Satanur		Kootagal		Dasavara	
Year	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
2008	**84.05**	**128.24**	**84.1**	**128.25**	**84.16**	**128.28**
2009	**74.68**	**122.42**	**74.72**	**122.47**	**74.90**	**122.44**
2010	**69.78**	**128.31**	**69.81**	**128.36**	**69.79**	**128.33**
2011	**83.85**	**124.29**	**83.89**	**124.33**	**83.86**	**124.31**
2012	**86.94**	**128.86**	**86.99**	**123.91**	**86.96**	**123.88**

Soil Erosion Studies

The soil loss in the Kanva catchment area is estimated using Universal Soil Loss Equation (USLE).The inputs for the model such as Soilmap, Landuse landcover map and slope map were derived from satellite Images of IRS PAN+ LISS –III after suitable ground truth studies.The slope map is prepared from SRTM data. Following formula is used in computation of Soil loss.

A=RKLSCP

Where, A is the computed soil loss in tons/hectare/year. R is the rainfall factor which is also called as erosion index EI which is taken from Isopleths for the present study it is taken as 250. K is the Soil erodibility factor which depends on the soil type. For the present study the weighted average value is calculated as 0.31.Lis the slope length factor and S is the slope steepness factor and the value of LS for the present study is calculated using Arc-Info GIS software. C is the crop management factor which is derived using land use and land cover map. P is the conservation practice factor. Since the study area comprises of field bunds the conservation factor is taken as unity.The above map layers were overlayed using Arc-Info GIS software and soil loss is computed in the Catchment The soil loss in the Catchment varies between 0 to 1500 tonns per hectare per year. The soil erosion map is shown as Fig-8.

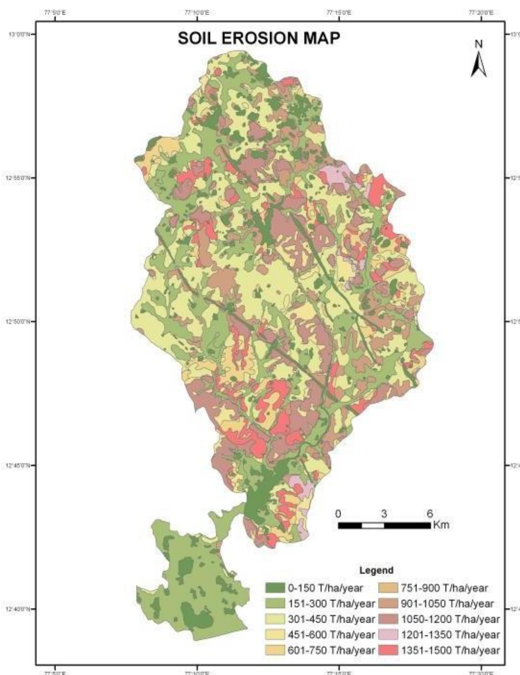

Fig 8 Soil Erosion map Runoff estimation using SCS-CN method

The (USDA, 1977) SCS Curve Number method is the most enduring method for estimating the volumes of direct,i.e., surface runoff from ungauged small catchments. In the present study SCS Curve Number method is used to estimate the surface runoff. The weighted curve number is derived by superimposing Hydraulic soil Group classification map and Land use and land cover map using GIS Arc-Info Software. The weighted Curve number of 71 obtained for the catchment is used to estimate the Runoff using the following equation.

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

$$S = \left[\frac{25400}{CN} - 254\right]$$

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Where Q is the Runoff in mm, P is the Rainfall in mm and S is the maxium soil water retention parameter and CN is the weighted curve number for the Catchment. The seasonal runoff is estimated using the seasonal rainfall data. For monsoon rainfall of 468mm for the year 2011 the estimated runoff is 163.03mm.

CONCLUSIONS

The results of the morphometric analysis helps in priotorising the sub catchments. The morphometric characters derived will help better management of the reservoir catchment which further helps in the management of the reservoir. The results of analysis of water and soil samples at various locations of catchment area revels that water is not suitable for irrigation and potable purpose and soil samples at various locations are deficient of Zinc, low organic carbon and low phosphorous, hence precautions should be taken to identify pollution potential zones and take prevention measures. From the results of field infiltration studies it is concluded that soils of the study area have medium to high infiltration capacities. It is observed from the computations of ETO by Penman-Monteith method for 5 years duration is between 79.8mm/month to 125.44mm/month. From soil erosion studies it is concluded that very severe erosion is observed in the catchment area hence proper measures has to be taken to prevent further soil erosion, which also helps in reduction of sediment upload into the reservoir. Thus SCS-CN method is an effective tool for estimating the runoff into the reservoir and also helps to analyse the reasons for reduced inflow into the reservoirs due to the various land use changes. The remote sensing and GIS is an effective tool of management of Reservoir catchment which in turn helps in the management of reservoir.

ACKNOWLEDGEMENTS

The authors wish to place on record their thanks to Management, Principal and Head of the Department of Civil Engineering of MEI Polytechnic, Rajajinagar, Bangalore, India and Management, Principal and Head of the Department of Civil Engineering of Dr.Ambedkar Institute of Technology, Malatahalli, Bangalore, India for there help and encoragemant for the present research work and preparation of this Paper.

REFERENCES

[1] USDA (1968): Diagnosis and Improvement of Saline and Alkali Soils, Agriculture Hand Book, No. 60, U.S.Salinity Lab. California, USA.

[2] Sadashivaiah.C., et al. (2008) Hydrochemical Analysis and Evaluation of Groundwater Quality in Tumkur Taluk, Karnataka State,India. Int J. Environ. Res. Public Health 5(3) P-158-164

[3] Ranganna, G., Chandrakantha, G., Gajendragad, M R., and K. Harshendra (1991): Studies on infiltration characteristics in soils of Pavanje river basin of Dakshina Kannada district (Karnataka State). Hydrology Jnl. of IAH, Vol XIV, No.1., pp. 33-40.

[4] Horton, R. E (1933): The role of infiltration in the hydrological cycle. Ame. Geophy. Union Trans. 14,pp. 446-460

[5] Lakshman Nandagiri and Gicy Kovoor (2006): Performance Evaluation or reference evapotranspiration equations across a range of Indian climates. Jnl. Irrigation and Drainage Engineering – ASCE; May/June, pp. 238-249.

[6] Kelley, W.P (1940). Permissible composition and Concentration of irrigation waters, pro.ASCE, P607

[7] K.C.Subhash Chandra, K.C., (1994) Occurrence of Groundwater and Aquifer Characteristics of Hard Rocks in Karnataka. Geo Karnataka Mysore Geological Department- Centenary Volume, P-338,342 and 343

[8] Soulis, K. X and J.D. Valiantzas (2012): SCS-CN parameter determination using rainfall-runoff data in heterogeneous watersheds-the two-CN system approach. Hydrol. Earth Syst. Sci. 16, pp. 1001-1015.

Geopolymer Concrete Subjected to Elevated Temperature: A review

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Abstract - In this paper will go through the various topics like alkaline activator content, various materials used for the production of geopolymer concrete, durability, mechanical properties, fresh properties and microstructure of the geopolymer concrete. Which shows the positive response than normal concrete, so the usability of geopolymer concrete has more impact on coming generation towards greener environment than normal concrete. Because ordinary Portland cement emits high amount of carbon dioxide than geopolymer concrete.

During any unpredictable situations like blast, fire , explosion etc. the geopolymer concrete has higher resistance till 4000c shows positive response to the strength compared to normal concrete. Hence the usability of geopolymer concrete may possess higher impact on coming up generation.

Keywords: Durability, alkaline activator, mechanical properties

INTRODUCTION

Geo as in earth, poly many and myr parts this organic polymer relies on its unique three-dimensional molecular nano-structure for its ultra-high performance. The Mine crafters are going to be familiar with the obsidian. Obsidian is the smooth black material of unequaled strength and blast resistance. The geopolymer obsidian is the number one choice of this generation of Mine craft engineers and architects when it comes to constructing high-performance structures.

Geopolymer concrete is also the number one choice of NASA's space engineers who are working with companies such as APUs core to develop robots to 3D print concrete made with lunar regolith and Martian sand in order to construct the first 3D printed space habitations on the moon and mars. This is a building designed by space exploration architects.

From the past years there is a much research was going on the development of the unique high performance geopolymer concrete.

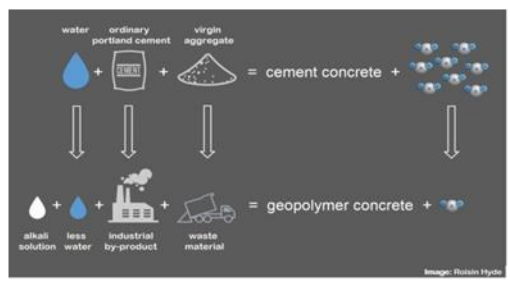

Figure1.1: Difference between geo-polymer concrete and ordinary concrete

This diagram depicts, the geopolymer concrete is a sustainable concrete and alternative to the normal concrete. Normal concrete is produced by using cement and water to bind virgin aggregate materials such as gravel and sand taken from quarries, riverbeds, and beaches not only this material relies on finite natural resources but this type of production leads to the emission of large volume of carbon-di- oxide. On the other hand geopolymer concrete uses the by-products of the industries such as GGBS, Bagasse Ash, quarry dust, agricultural waste and recycle construction aggregates to produce high- performance low impact concrete.

LITERATURE REVIEW

2.1 Fly ash based geopolymer concrete

Badami Bhavin., et.al., [1] explains the impact of cement production on climatic change and environmental pollution. In this study, flash acts as a binder instead of OPC and the aggregates occupy 75 to 80 percent of the volume. There is three trial mix proportion with the varying fly ash, alkaline, and water content in order to obtain the optimum mix. They wrapped vacuum bagging film to minimize the evaporation of water from the concrete. The curing methods adopted are steam curing and dry curing. The GPC concrete shows a higher compressive strength up to 62 MPa whereas the OPC results up to 21.7 MPa. The cost-benefit analysis in the paper presents that for one cubic meter of OPC concrete is Rs 4562 against the GPC concrete which is Rs 3187 proves to be economical and cost-effective by 43 percent of the conventional concrete. Instead, this geopolymer concrete provides good resistance to the corrosive environment like an acid attack.

Sujay Nanavati., et.al., [2] explains the awareness of the alternative binder geopolymer concrete which can be used in precast industries as well as checking the feasibility for the in-situ condition. This paper reviews various materials used for manufacturing concrete such as Fly ash, alkaline liquids, aggregates, superplasticizers. Fly ash plays a good role as an artificial pozzolan, Low calcium fly ash is preferred to use as source material than the high calcium fly ash. The alkaline liquids such as sodium hydroxide and sodium silicate are preferred over potassium hydroxide and potassium silicate in order to be economic. Aggregates comprising of 80% of the volume of concrete which is even the same for the OPC concrete. The super-plasticizers are preferable for better workability. Sunlight curing helped instead of steam curing or over curing. The compressive strength was 1.54 times higher than controlled concrete, the split tensile strength was 1.45 times higher than controlled concrete, the flexural strength was 1.6 times higher than the controlled concrete. The acid resistance of GPC concrete weight reduction was 1.6% decreased in 82 days. The fly ash solves the problem of landfills.

JeetendraAhirwar et.al., [3] explains the waste generated from the demolition in India is about 530 million tonnes every year, which causes a serious problem of disposing of it. Based on study 3 different mix proportion of geopolymer concrete are considered which yields better results. The impact value of the demolition aggregates was 12.26%, After

the casting, the test specimens are heat cured at 80 degrees for 24 hours. From the three different mix proportions, this mix proportion 1:1.5:3 yields the best than the other two mix proportions which are 1:1.75:3.25 and 1:1:1.85. the fly ash-based concrete with 100% replacement decreases the strength of about 5 to 10%, even the split tensile strength also decreases. The fly ash based geopolymer concrete solves the problem of disposal in India and also helps to overcome the environmental pollution.

2.2 Sugarcane Bagasse ash Based geopolymer concrete

ErniSetyowati., et.al., 2014[4] explains the world is facing global climate change due to the pollution caused by the industries mainly the cement production which alone causes 7 percent of the total emissions of CO2viz 930 million tonnes per annum. Usage of Styrofoam and the bagasse ash in the concrete makes it aerated concrete which has sound insulation property. The silica content in the chemical composition of the bagasse ash sample is 71 percent. The strength of the concrete decreases after 15% replacement. The usage of waste material leads to the economic approach and improves the value of waste eliminating the problem of disposal. The structure can be earthquake resistant because of the reduction in weight which can help in the earthquake zones.

The pores in the Styrofoam helps in additional special quality in the concrete which is sound insulation. Hence it solves the problem of waste disposal.

Tony SumanKanth D et.al., [5] explains the universe is facing the environment pollution due to the emission of pollutants from the industries to the atmosphere which one of them is cement production which contributes about 8% of total emissions of CO2 in the world. The 24 specimens cast for the study which are cubes, cylinders and the beams each of size 150mmx150mmx150mm, d-150mm h-300mm and 100mmx100mx500mm respectively.

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The various controlled factors are taken care such as the heat curing at the rate of 60 degrees for 24 hours, the 12M concentration of NaOH, SSD basis aggregates with varying percentage of bagasse ash and rice husk ash. As the percentage of replacement increases the strength decreases which shows up to 10 percent replacement level the strength was good. The geopolymer concrete gives the early strength of 75% in 7 days which helps in the progress of the work in construction areas. This is preferable for the water shortage area.

Buari T.A et.al., 2015[6] explains the concrete is the second most consumable material after water which leads the circumstance in waste management, the research on sustainable approach can be adopted to solve the issue of waste. SCBA with varying percentages 5%, 10%, 15%, 20% are considered for the further study, initial and final setting time are 225 minutes and 252 minutes respectively, two types of curing are taken into account which is controlled condition and salt condition are the factors affecting. The SCBA of specific gravity 1.44 and moisture content 0.46 are the preliminary and the chemical composition of the sample with silica of 22 percent. SCBA is a good pozzolanic material which forms the CSH reacting with calcium hydroxide, the pozzolanic activity is favorable in the normal environment and increases with time. The specific gravity is very less than OPC which depicts the greater volume of cementitious material in a huge mass of replacement. The compressive strength at the stake of 10 percent proves a good strength can be used for the construction of masonry wall etc. This solves the problem of waste management and its one way for a sustainable approach to achieve.

2.3 GGBS Based geopolymer concrete

Parukutty S. Ambily et.al., [7] explains the ultra-high performance concrete using the wastes such as industrial and agricultural by-products in order to attain efficient and eco-friendly concrete. The GGBS, silica fume and fly ash are the source materials with the silica content 43.4, 94.73 and 62.1 respectively. the curing condition for the specimen is the ambient curing, four mix proportion with steel fibers and one without steel fibers. The mix proportion with steel fibers influences higher strength than the concrete without steel fibers, the highest average compressive strength was 175 MPa with the steel fibers of 1% of 6mm and 2% of 13mm and the highest average compressive strength was 124 MPa without steel fibers. The flexural strength of specimens with and without steel fibers are 13.5 MPa and 9.1 MPa respectively. hence the geopolymer concrete can be ultra high performance, efficient, eco-friendly and sustainable.

Padmanaban M Set.al., [8] explains geopolymer concrete is the alternate way to OPC concrete, which is made by using the source material and alkaline solution. The mix proportion for M30 normal concrete and geopolymer concrete are tabulated. The basic tests such as, sieve analysis, water absorption, specific gravity for the materials such as cement, GGBS, FA, and CA. The specific

Gravity for cement, GGBS, FA are 3.15, 2.75, 2.44 respectively with the constant of 8M molarity of NaOH. The water absorption in geopolymer concrete is lesser than the OPC concrete. The compressive strength, split tensile strength and flexural strength of geopolymer concrete are higher than the OPC concrete. The mix proportion with 77% volume of aggregates shows the higher strength with the age, the strength gain in geopolymer concrete is higher at the early age of 7days followed by the decrease in strength as the concrete ages. Geopolymer concrete can be an innovative use of construction material in the industry with benefits such as eco-friendly and economical than the OPC concrete.

2.4 OPC concrete under elevated temperature

Tomasz Drzymałaa et.al., [9] explains the behavior of the high-performance concrete under elevated temperatures for different types of HPC such as reference concrete, polypropylene, fiber-reinforced concrete air entrained concrete, and. The thermocouples are placed at the corner, core and to the side surface to measure the temperature inside the furnace. The strength increases up to 400 degrees followed by the decrease in the strength from 450 degrees to 800 degrees up to a maximum loss of 56%. The PFR HPC modulus of elasticity decreases as the temperature increases. After the test specimens exposed to the elevated temperature, the following observations are made the concrete becomes brittle and losses its weight, the color changes, and the fine cracks start after 450 degrees.

 ISBN: 978-93-90214-19-8

The air entrained concrete is the alternative solution PRF HPC because of its better resistance to temperature.

NesrineKhodja et.al., [10] explains the behavior of concrete under elevated temperature for HPC with 10% silica fume and the normal concrete. The water-cement ratio of 0.5 for normal concrete and the HPC concrete with a water-binder ratio of 0.32 are maintained throughout, the rate of heating is 7 degrees per minute. The residual compressive strength decreases with increase in temperature, in the range of 600 to 900 degree the decompose of the CSH gel leads to the strength degradation. Due to thermal shock, the mechanical properties were observed in the OPC concrete and HPC concrete which are 81% and 91% respectively. The HPC concrete with a 10% silica fume improved the compressive strength than the OPC concrete at room temperature . Temperature inducing in the specimen changes the composition in concrete which causes cracks. The HPC can have various types of crack such as trans angular cracks and the cracks surrounding the concrete.

2.5 Geopolymer concrete subjected to elevated temperature

Anwar Hosan et.al., [11] explains the effect of various activators such as sodium and potassium based by the change in physical properties and the compressive strength which are subjected to elevated temperatures ranging from 200 to 8000 C after the age of 28 days. The sodium based geopolymer shows the higher compressive strength at the ambient condition further a good resistance up to 400 degrees than the potassium-based geopolymer. At 600 degree the strength of the potassium-based geopolymer is higher than the sodium based geopolymer. The geopolymer with potassium exhibited higher resistance to all the elevated temperature than the sodium based geopolymer. The volume shrinkage of the K-geopolymer is lower than the Na-geopolymer. The K-geopolymer with AAS ratio of 3 shows the maximum residual strength in every elevated temperature than the Na-geopolymer. The k-based geopolymer exhibited minimal cracks on the surface than the Na-based geopolymer.

Faiz Shaikh et.al., 2018[12] explains the study on potassium-activated geopolymer under elevated temperature using the carbon and the basalt fibers by varying the percentage of replacement 0.5, 1 and 1.5%. There are 35 series of the geopolymer specimen where six whereof the additive replacement as described above. The 1% weight of carbon and 1% of basalt fibers improves the stability of the geopolymer, good compressive strength, minimal volume shrinkage and lesser weight loss than the other fiber subjected to elevated temperature. At 800 degree the cracking on 1% weight carbon reinforced geopolymer was less than the basalt based geopolymer. The higher compressive strength, the lower shrinkage volume and the lower weight loss in carbon fiber fly ash geopolymer at the different level of temperature up to 800 degrees have the important role to play as a filler media in the geopolymer. The results indicate that the carbon-based geopolymer has a better bonding in the matrix than the basalt based hence it's preferred to use the carbon-based geopolymer for better resistance geopolymer matrix with good strength and many more advantages.

2.6 Durability of Geopolymer concrete

R.Venkateshan, K.Pazhani et.al.,[13] study was made on the durability properties of GPC used GGBS as primary binder and black rice husk ash (BRHA) was used as a replacement material for cement upto a proportion of 10 to 30% , conducted tests such as sorptivity, rapid chloride permeability test. Results revealed that strength developed will be reduced beyond the 10% replacement of BRHA and yet strength was well up to 20% replacement levels and durability significantly improved with addition of BRHA with that of reference concrete.

R. Scholar , K. babu et.al.,[14] presents the durability of GPC of fly ash based with sodium hydroxide and sodium sulphate as alkali materials, with varying the content of fly ash from 350 to 550 kg/m3 and alkali activator solution to binder ratio of 0.4 & 0.5. Results revealed that water absorption property is inversely proportional to strength of concrete and fly ash content. Concluded that GPC exhibit the excellent resistance to acid attack with that of normal concrete.

ISBN: 978-93-90214-19-8

Conclusion

• Strength developed in geopolymer concrete is high when compared to normal concrete.
• Early strength developed (90% strength will be gain in 3 to 7 days) which helps in removing scaffolding early.
• Resistance to temperature and spalling is high compared to normal concrete.
• Economical in large scale usage.
• Sustainable use of waste materials helps to overcome problem of land filling.
• There is very minimal requirement of water which helps in water sustainability or water conservation.

References

[1] BadamiBhavin (2013). "Geopolymer Concrete and Its Feasibility InIndia", Proceedings of National Conference CRDCE13, 20-21 December 2013, SVIT, Vasad.
[2] SujayChetanNanavati (2017). "A Review on Fly Ash-based Geopolymer Concrete", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Volume 14, Issue 4 Ver. VII (Jul. - Aug. 2017), PP 12-16.
[3] JeetendraAhirwar(2018). "Compare the Strength of Fly Ash-Based Geopolymer Concrete with Demolition Waste", SSRG International Journal of Civil Engineering (SSRG - IJCE) – Volume 5 Issue 1 – January 2018.
[4] ErniSetyowati(2014). "Eco-Building Material of Styrofoam Waste and Sugar Industry Fly-ash Based on Nano-Technology", Procedia Environmental Sciences 20 (2014) 245 – 253.
[5] Tony SumanKanth D(2015). "Hardened Properties of Bagasse Ash GPC and Rice-husk Ash GPC", International Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Issue 12, December 2015.
[6] Buari T.A(2015)."Durability Of Sugarcane Bagasse Ash Blended Cement Concrete Under Different Sulphate Concentration", Department of Building Technology, Federal Polytechnic Ede, Osun State, Nigeria.
[7] Parukutty S. Ambily (2017). "Development of ultra-high performance geopolymer concrete", Magazine of Concrete Research, 2014, 66(2), 82–89.
[8] Padmanaban M S (2018). "Geopolymer Concrete With GGBS (Ground Granulated Blast Furnace Slag)", International Journal of Engineering Sciences & Research Technology7(2): February 2018.
[9] Tomasz Drzymałaa (2016). "Effects of High Temperature on the Properties of High-Performance Concrete (HPC)", Procedia Engineering 172 (2017) 256 – 263.
[10] NesrineKhodja (2018). "Effects of Elevated Temperatures on Mechanical's concrete specimen behavior",MATEC Web of Conferences 165, 22010 (2018).
[11] Anwar Hosan(2016). "Compressive behavior of sodium and potassium activators synthetized fly ash geopolymer at elevated temperatures: A comparative study", Journal of Building Engineering 8 (2016) 123–130.
[12] Faiz Shaikh(2018). "Behaviour of Carbon and Basalt Fibres Reinforced Fly Ash Geopolymer at Elevated Temperatures", International Journal of Concrete Structures and Materials, ISSN 1976-0485, 2018.
[13] Venkatesan, R. P. and Pazhani, K. C. (2016) 'Strength and durability properties of geopolymer concrete made with Ground Granulated Blast Furnace Slag and Black Rice Husk Ash', KSCE Journal of Civil Engineering, 20(6), pp. 2384–2391. doi: 10.1007/s12205-015- 0564-0.
[14] Scholar, R. S.- and Babu-, K. G. (2008) 'Durability Study of Low Calcium Fly Ash', Journal Article, (January 2008), pp. 1153–1159.

Literature Review on Specific Seismic Hazard Analysis

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Abstract - Seismic hazard studies are important to reduce the seismic risk. Primary aim is to develop consistent seismic ground motion. If sites located in seismically active regions, then site-specific seismic hazard studies are essential to mitigate the seismic risk of the site. Tectonic framework of Bangladesh and adjoining areas indicate that Bangladesh lies well within an active seismic zone. The mega city Dhaka in Bangladesh is considered by many researchers as one of the riskiest cities in the world due to many non-engineered construction practices and poorly studied tectonic boundary conditions. The city is built on a Plio-Pleistocene terrace, located within the subsiding Bengal basin. The records of historical earthquakes indicate that three large magnitude earthquakes occurred during the last 150 years within and in close proximity to Bangladesh. Magnitudes of these earthquakes ranged from 6.9 to 8.7 occurring between 1885 and 1918. These events caused moderate damage to buildings and other infrastructures in Bangladesh

Keywords: Seismicity in Bangladesh, probabilistic seismic hazard assessment (PSHA), Earthquake data, seismic record, peak ground acceleration, Seismic hazard.

INTRODUCTION

Seismic Hazard Analysis has become an increasingly important tool for aiding design and decision making at all levels in both the private sector and government. The level of sophistication applied to Seismic Hazard Analysis has increased dramatically over the past 27 years since the technique was first introduced in the literature. As more and more people and groups implemented and used Seismic Hazard Analysis in different forms, it became clear to the sponsors of the Senior Seismic Hazard Analysis Committee (SSHAC) report that the time had arrived to establish more uniform and up-to-date guidelines for future SHA studies.

STUDY OF SEISMIC HAZARD

Sismic hazard is probability that an earthquake will occur in an given geographical area. It also provide span of time and ground motion intensity. Sismic hazard was first calculated by C.Allin Cornell in 1968. In this calculations the regional geology ans seismology is first examined for sources and patter of earthquake occurrences. Both depth and surface patterns are examined from seismometer[4]. The adopted procedure for the study of site specific seismic hazard analysis is mentioned in IS code

DATA COLLECTION OF GEOLOGICAL CONDITION

The fault map of India prepared from the GSI(2000) is shown in Figure 1. Based on the geology and tectonic setup, India can be broadly divided into three zones: the Himalayan region, the Gangetic plain, and the Indian shield. It can be observed that Bangladesh lies in the Indian shield region The flexural stresses along with the northwest compressive stress of collision are responsible for sporadic earthquake occurrences within the Indian plate. The great structural disturbances during the geological past resulted in the development of local zones of weakness along which crustal adjustments are likely to take place[12][13].

Seismic data collection and tectonic background

The seismotectonic map (Figure 1) shows that there are some regions that are more active than others. There is a possibility that not all past epicenters can be uniquely identified with particular faults. The distribution of faults varies spatially as seen from Figure 1[14]. Some specific patterns can be recognized about the faults and epicenters being dense in some regions. This pattern and the known tectonic disposition of India can be used to demarcate source zones for further work. Recently NDMA (2011) document on PSHA map of India divides India into 32 homogeneous seismic source zones based on historical seismicity, tectonic features and geology[12]. These zones along with the faults within each zone are shown in figure 2. It can be observed that the ground motion at the site is influenced by events occurring on faults located in the neighboring seven zones surrounding the site.

Earthquake Catalogue

Earthquakes of magnitude ≥ 3 around the Bangladesh from 325 BC to 2015 are taken from the reports of NDMA (2011), Raghukanth (2011) and USGS website (http://neic.usgs.gov/). A total of events for have been collected for the site [13]. A list of earthquakes with magnitudes Mw ≥ 6 in the historical and instrumental period is reported in Table 1.

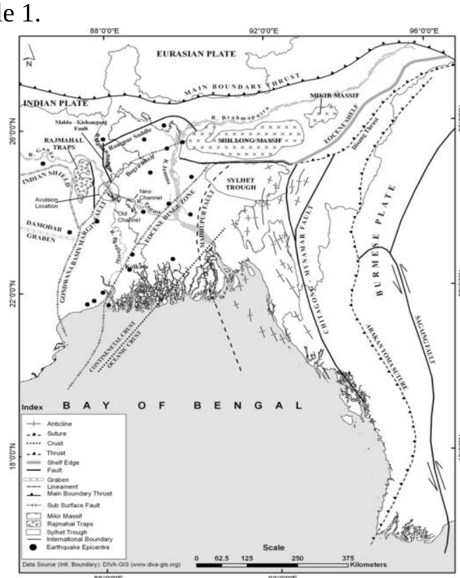

FIGURE 1. SEISMOTECTONIC MAP OF BENGAL BASIN (WWW.RESEARCH.NET)

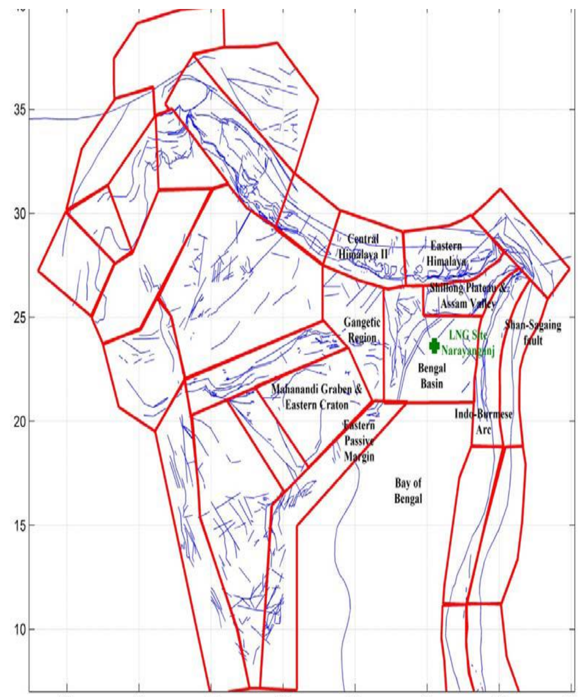

Figure 2. Seismogenic zones of India superimposed with faults (NDMA 2011)

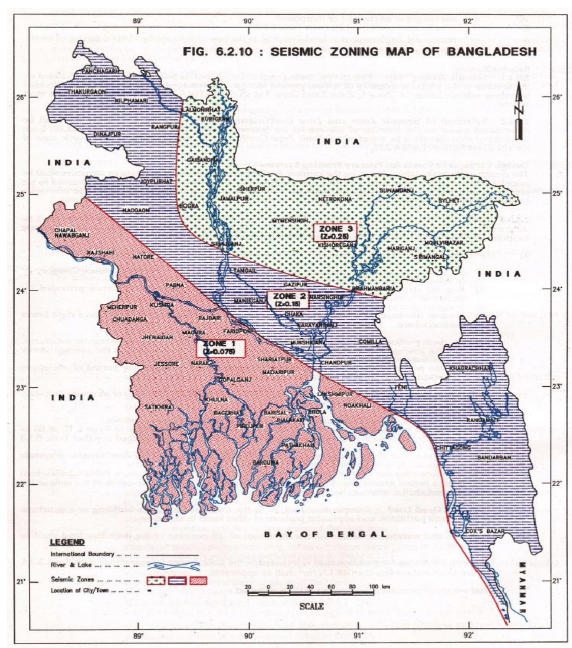

Figure 3. Seismic Zoning Map in BNBC-1993 [13]

ISBN: 978-93-90214-19-8

Table 1. List of Major Historical Earthquakes Affecting Bangladesh [13]

Date of occurrence	Name (Place)	Magnitude	Epicenter distance from Dhaka(Km)
10 Jan 1869	Cachar Earthquake	7.5	250
14 Jul 1885	Bengal earthquake(Bogra)	7.0	170
12 Jun 1897	Great Indian Earthquake	8.7	230
08 Jul 1918	Srimangal Earthquake (Srimangal)	7.6	150
02 Jul 1930	Dhubri Earthquake	7.1	250
15 Jan 1934	Bihar-Nepal Earthquake(Bihar)	8.3	510
15 Aug 1950	Asam Earthquake (Aasm)	8.5	780

CONCLUSION

This paper gives a brief account of several local as well as global seismic hazard assessment studies. These are earthquake locations suggested by recent seismological studies but insufficient historical proofs. Particular sites have advantage of eliminating risk of seismic hazard. In some cases intensities for cumulative distribution function is zero. Shear wave velocity of geological bedrock are lower than expectation of experts. Found that the problem could not be reduced to single peak acceleration. After effects of earthquake are disastrous and therefore what mankind can do is only to take precautionary measures. It is imperative to install suitable number of seismic stations so that in future, site specific real earthquake records for all over global development. As the building period increases the short period isolators show some amplification with height but this is slight. Applying a probabilistic seismic hazard assessment (PSHA) to a project typically requires determining the level of hazard of concern. The value of the completely probabilistic approach is that a true probabilistic estimate can be calculated that incorporates the uncertainty in our knowledge of site amplification of ground motions.

REFERENCES

[1] Jaykumar Shukla, Deepankaar Choudhary "Seismic hazard and site-specific ground motion for typical ports of Gujarat" Springer Science+Business Media B.V. 2011, 25 November 2011

[2] Md. S. Bari. T. Das, "A comparative study on seismic analysis of Bangladesh National Building Code (BNBC) with other building codes", J. Inst. Eng. India Ser. A, 15 March 2014

[3] C.Allin Cornell, "Engineering Seismic Risk Analysis", Bulletin of the Seismological Society of America, vol. 58, October 1968

[4] Dr. Jens-Uwe Klugel, " How to eliminate Non-damaging earthquake from the results of a probabilistic seismic hazard analysis (PSHA) – A comprehensive procedure with site specific application", Transactions, SMiRT 19, Toronto, August 2007

[5] Alireza Haji-Soltani,"A comprehensive site-specific probabilistic seismic hazard analysis for a liquid natural gas tank located in the gulf coast region", The University of Memphis, pp. 29- 80, May 2017

[6] Ankit Gupta, Kapil Mittal "Seismic Microzonation : A Case Study" Civil Engineering Research Journal ISSN 2575-8950, Volume 1, August 2017.

[7] A. B. M. Saiful Islam, M. Jameel, M. A. Rahman and Mohd Zamin Jumaat "Earthquake time history for Dhaka, Bangladesh as competent seismic record" International Journal of the Physical Sciences Vol. 6(16), pp. 3923-3928, 18 August 2011.

[8] A. B. M. Saiful Islam, Mohammed Jameel, Syed Ishtiaq Ahmad and Mohd Zamin Jumaat "Study on corollary of seismic base isolation system on buildings with soft storey" International Journal of Physical Sciences , June 2011.

[9] Stephanie L. Ross, Homa J. Lee, Tom E. Parsons " Comments on Potential Geologic and Seismic Hazards Affecting Proposed Liquefied Natural Gas Site in Santa Monica Bay, California", U.S. Geological Survey, Reston, Virginia 2008

[10] Chris H. Cramer "Site-Specific Seismic-Hazard Analysis that is Completely Probabilistic" Bulletin of the Seismological Society of America, Vol. 93, No. 4, pp. 1841–1846, August 2003

[11] Fatemeh Jalayer "direct probabilistic seismic anaysis: implementing non-linear dynamic assessments"the deparment of civil and environmental engineering and the committee on graduate studies of stanford university" , March 2003.

[12] Ali MH, Choudhury JR, "Tectonics and earthquake occurrence in bangladesh. paper presented at 36th annual convention of the institute of engineers", Bangladesh, Dhaka,1: 4-8, 1992.

[13] Ali MH, Choudhury JR, "Seismic zoning of bangladesh. Paper. presented at the international

seminar on recent developments in earthquake disaster mitigation organized by institution of engineers bangladesh in association with world seismic safety initiative.", Bangladesh, Dhaka, 1994.

[14] Tahmeed M. AL-Hussaini, Ishika N. Chowdhury and Md. N. A. Noman "seismic hazard assessment for bangladesh-old and new perspectives", First International Conference on Advances in Civil Infrastructure and Construction Materials, December 2015.

[15] C. Y. Lin, M. Wu, J. A. Bloom, I. J. Cox, and M. Miller, "Rotation, scale, and translation resilient public watermarking for images," IEEE Trans. Image Process., vol. 10, no. 5, pp. 767-782, May 2001.

Methods for Upgradeation-Prioritization of Rural Roads-A Review

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Abstract - A well-planned road network in rural areas is one of the most important infrastructure elements which improves rural accessibility and contributes to the rural development as a whole. To improve the connectivity among villages and also toward the public facilities, there is an urgent need to improve the condition of existing roads by planning for upgradeation. Upgradeation of rural road is very important because lack of upgradation of these roads increases the time for access to market and other social infrastructure to rural community. If pavement condition is not evaluated properly then it is very difficult to take correct decision for upgradation of rural roads in future. Due to limited financial resources for upgradeation of rural roads there is always need to have decision making tool which will decide priority of particular road upgradeation. The research study can be taken to identify methods of prioritizing upgradeation of rural roads with influencing factors which should be considered during prioritization of upgradation of rural roads.

Keywords: Rural road, upgrdaeation, prioritization, methods etc.

INTRODUCTION

Rural Connectivity becomes a critical component in the socio-economic development of rural people by providing access to amenities like education, health, marketing etc. Upgradeation of rural road is very important because lack of upgradeation of these roads increases the time for access to market and other social infrastructure to rural community. The research study can be taken to identify methods of prioritising upgradeation of rural roads with the influencing factors or variables that should be considered during prioritization of upgradeation of rural roads.

LITERATURE REVIEW

The literature reviews are carried out to understand the methodology adopted by various researchers for deciding the priority of up gradation of roads.

Kanuganti, Dutta, Sarkar, Singh et.al. (2017), Investigated development of a Need – Based Approach for Rural Road Network Planning. Steps are being taken to develop a need based approach for village connectivity.

$$Accessibility\ Indicator\ (AI) = \frac{Total\ Population\ access\ to\ facilities}{Total\ Population} \quad (1)$$

Anil Modinpuruja, C.S.R.K.Prasad, Mukesh Chandra et.al. (2016) developed Facility-Based Planning Methodology for Rural Roads using Spatial Techniques. A priority list of the road links to upgradeation works is prepared by calculating the link weight using gravity formula.

$$Weightage = Wij = \frac{(Pi^{*} Pj)^{*}(Fi - Fj)}{d\text{^}2} \quad (2)$$

K.Shalini, Prof.Ashok Kumar Sarkar, Prof.Ajit Pratap Singh et.al. (2015) developed Qualification of Rural Accessibility and development of a Need-Based Approach for Rural Road Network Planning**.**

$$Ai = \sum_{j} Rj * f(d_{ij})^{*} Fj \quad (3)$$

$$Fj = \frac{dm^{*} dij}{dm} \quad (4)$$

Pradeep Kumar Samanta, et. al. (2015) developed the techniques on development of rural road infrastructure in India. Ramesh et.al. (2013), developed facility based Rural Road Planning Techniques which proposed Model for calculation of Network Performance Index based on accessibility Index of all the village presents in the analysis area.

$$NPI = \Sigma_{AI} = \Sigma \left[\frac{P_i * \Sigma_{j=1} \frac{Pj}{Lij * \delta ij}}{P} \right] \quad (5)$$

Bhrargab Maitra, Moen Azmi, S.N.Ibrahim, et.al. (2011), developed prioritization of Road Projects- A Dis-utility Approach for the prioritization of road development.

Total disutility for existing road 'j' =

$$U_j = -\Sigma_i a_i{}^{\wedge} n * X_{ij}{}^{\wedge} n \quad (6)$$

Keerthi M.G. Prof.Anjaneyulu, etal. (2007) developed Rural Road Network Planning using GIS Prioritize the settlements by its Utility Value.

$$SI_i = \Sigma_x W_{xi} \quad (7)$$

Shrestha et. al. (2004), investigated a Computer – Aided Methodology for District Road Network Planning and Prioritization in Nepal**.**

$$Centrality\ Index = C_j = \Sigma_{i=1}^{n} (W_i * X_{ij}) \quad (8)$$

Where X_{ij}= value of i[th] function (number of establishments or shops at the jth market center;

Wi = Weightage of j[th] function = (Median Population of i[th] function/ lowest median population of market centres where a function exists).L.R.Kadiyali, N.B.Lal, etal. (2003), presents the road network in form of rooted spanning trees,

$$Q = p + \frac{m}{\sqrt{d}} + \Sigma_{i=1}^{n} \frac{q_i}{ri} \quad (9)$$

A.K.Mahendru, et. al. (1983), developed Linkage Pattern in Rural Road Network Planning. Mahendru suggested the concept of settlement interaction by Demographic Force Method in his study which shows that the road which has higher Demographic Force will be priority-1 for upgradeation

$$Fij = \frac{P * CS}{\frac{2}{Dij}} \quad (10)$$

OBJECTIVES

The comprehensive review of the literature indicated that there are many approaches for upgradeation prioritization of rural roads. The broad objectives of the study are as:

i. To identify methods based on minimal spanning tree concept, inter settlement interaction approach, accessibility criteria etc are more rational and scientific approaches to rural road upgradeation.
ii. To analyze the various methods of upgrading prioritization of rural roads

PRIORITIZING METHODS

After studying various upgradeation and prioritization method in literature review, the following methods are being selected in the study.

NEED-BASED METHOD:

Kanuganti, Dutta, Sarkar, Singh et.al. (2017), Investigated development of a Need – Based Approach for Rural Road Network Planning. Steps are being taken to develop a need based approach for village connectivity.

$$Accessibility\ Indicator\ (AI) = \frac{Total\ Population\ access\ to\ facilities}{Total\ Population}$$

FACILITY-BASED METHOD:

Anil Modinpuruja, C.S.R.K.Prasad, Mukesh Chandra et.al. (2016) developed Facility-Based Planning Methodology for Rural Roads using Spatial Techniques. A priority list of the road links to upgradeation works is prepared by calculating the link weight using gravity formula.

$$Weightage = Wij = \frac{(P_i * P_j)*(F_i - F_j)}{d^{\wedge}2}$$

UTILITY FACTOR METHOD:

Utility Factor Method is generally used in operational manual of 'Pradhan Mantri Gram Sadak Yojana to decide the priority for upgradeation the values in ascending order, higher utility value of road will be at first priority and lower value of utility value will be at the last priority.

$$utilityvalue = \frac{totalWeightage}{LengthofRoad}$$

NETWORK PERFORMANCE INDEX METHOD:

Ramesh etal. (2013) presented model for calculation of Network Performance Index based on accessibility Index of all the village present in the analysis area.

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$$NPI = \sum_{AI} = \sum \left[\frac{P_i * \sum_{j=1} \frac{Pj}{Lij * \delta ij}}{P} \right]$$

DIS-UTILITY FACTOR METHOD:

Bhrargab Maitra, Moen Azmi, S.N.Ibrahim, et.al. (2011), developed prioritization of Road Projects- A Dis-utility Approach for the prioritization of road development.

Total disutility for existing road 'j' = $U_j = -\sum_i a_i{}^{\wedge}n * X_{ij}{}^{\wedge}n$

DEMOGRAPHIC FORCE METHOD:

A.K.Mahendru, et. al. (1983), developed Linkage Pattern in Rural Road Network Planning. which shows that the road which has higher Demographic Force will be priority-1 for upgradeation

$$Fij = \frac{P * CS}{\frac{2}{Dij}}$$

CONCLUSION:

After comprehensive literature review it can recommended that the various prioritizing methods for upgradeation of rural roads are

a) Need Based Method
b) Facility based Method
c) Utility Factor Method,
d) Network Performance Index Method
e) Dis-Utility Factor Method
f) Demographic Force Method

ACKNOWLEDGEMENT:

Inspiration and motivation have always played a key role in success of any venture. It is great sense of accomplishment to express our sincere gratitude to my respected guide Dr. Prashant P. Nagrale (Professor & Dean Finance SPCE Andheri) for the constant interest, encouragement and valuable guidance. I would like to extend my gratitude to Dr. Mohan M.Murudi.(I/C Principal , SPCE Andheri), for the support and also thanking to Dr. Anil N. Ghadge, (PG Coordinator, SPCE ,Andheri) for his valuable suggestion and to everyone who their own special way helped me.

REFERENCES

[1] Shalini Kanuganti, Bhupali Datta, Ashoke kumar Sarkar, Ajit Pratap Singh (16 June 2017), "Development and Need –Based Appraoch for rural Road Network Planning." Springer international Publishing, Switzerland.

[2] Anil Modinpuroji, C.S.R.K.Prasad, Mukesh Chandra, (22Sept.2016), "Facility –Based Planning Methodology for Rural Roads Using Spatial Techniques." Springer international Publishing, Switzerland

[3] K.Shalini, Prof. Ashoke Kumar Sarkar, Prof.Ajit Pratap Singh (2015), "Quantification of Rural Accessibility and Development of Need Based Approach for Rural Road Network Planning."

[4] Dr. Pradeep Samanta (2015) "Development of Rural Road infrastructure in India" Pacific business review International Vol.7, pp.86-93.

[5] Ramesh et.al. (2013), "Facility Based Rural Road Planning Techniques".

[6] Bhragav Maitra, Moen Azmi, S.N.Ibrahim, (19dec.2011). "Prioritization of Road Projects- A Disutility Based Approach", Transport 2002, Volume XVII, No.2, pg 52-56, Taylor & Francis.

[7] Keerthi M.G. Prof.Anjaneyulu, etal. (2007), "Rural Road Network Planning using GIS Prioritize the settlements by its Utility Value".

[8] Chandra B. Shrestha (5 Jan.2004), "Devolving Computer –Aided Methodology for District Road Network Planning and prioritization in Nepal" International Journal of Transport Mangaement1 (2003)157-174, Science Direct

[9] L.R.Kadiyali, N.B.Lal, (2003), "Principles and Practices of Highway Engineering" Khanna Publisher, Delhi, Fourth edition: 2003, pp.639-641.

[10] A.K.Mahendru (1983), "Linkage pattern in Rural road network planning," Journal Indian Road Congress, Vol.44-3, pg.649-675.

[11] Operation Manual National Rural Roads Development Agency, Ministry of Rural development Government of India (February 2005).

Sediment Size Variation in Field Sampled Bed Load Transport of an Ephemeral Mountain River

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Abstract*— Ephemeral channels are ever changing like chameleons and constantly challenges the field researchers. Sampling of bed load and suspended load in a quick response mountainous channel is a test of coordination, skills and luck. The channel shows great variation in sediment size distribution of bed load sediment transport over space and time. The measurement in the field indicates that the variation in sediment size in bed load not only depends upon the favorable slope and thereby flow velocity, but also the sediment fed from the upstream. The single large sediment can affect the whole distribution in a gravel bed stream. The flash floods after the precipitation causes large particles to move due to sudden flow thrust. This could dislodge other large and small sediments in bed during its movement. The movement of large sediment causes variation in sampling as it comes closer to entrance of a bed load sampler. The bed load sampling carried out collected using modified Helley Smith Sampler in a mountain ephemeral river of Gujarat revealed large variation in the sediment size. Sudden spikes in the median diameter of the sediment sample leads to large error in prediction of bed load transport rate using various bed load equations given by different researchers. This significantly and adversely affect the chances of finding an appropriate bed load equation suitable for the study river and often compels field engineers to rely on thumb rules of estimating sediment transport rate, which may sometimes lead to undesirable surprises. This study aims to give an idea about the extent to which this variation in the sediment size is generally observed.

Index Terms—*Bed load transport, HS Sampler, mountain river, sediment sampling, Sediment distribution*

I. INTRODUCTION

Sediment transport rate is an important natural phenomenon. This behaviour of river can significantly affect the design and performance of a hydraulic structure through varying and unpredictable process of erosion and deposition. The dependency of sediment transport phenomenon on large number of stochastic parameter is highlighted by many researchers and is now a common understanding. The attempts to predict mathematically or analytically, the sediment transport behaviour of a channel has found limited success in application. The practical solutions for practicing field Engineers still remain to trust some selected empirical equations suggested by different authors using different approaches. The validity of these equations vary from site to site, sometimes giving large errors, and thus offers no universal solution. Some thumb rules based on the discharge in the river and bed and boundary characteristics can be used for small projects. Any large project across the river requires long term sediment discharge data largely unavailable in Indian context. This highlight the relevance and necessity of field measurement of sediment transport during different discharge conditions.

Sediment transport comprises of Bed Load, Suspended Load and Wash load, often considered as part of Suspended load. CWC (Central Water Commission) has been actively measuring the suspended sediment concentration at different points along with gauge and discharge in the rivers of India. However, some smaller streams, though significant in local context, are still out of its coverage. Such smaller streams include ephemeral rivers in mountain and hills. These streams lack the sediment transport data which is even more important for structures in the hilly region. The regular measurement of Bed Load has not been pursued by any government body or public/private enterprise like construction companies.

The measurement of bed load is a challenging task. It involves the measurement of following parameters:
1) Geometrical Parameters- X-section, Longitudinal slope, side slope, Lateral Slope, Bed Forms, etc.
2) Flow Parameters-Velocity, Depth, Temperature, etc.
3) Sediment Parameters- Concentration, Rate, Density, GSD, etc.

The field measurements in a hilly ephemeral stream are even more challenging. The large spatial and temporal variation of flow characteristics can affect the sediment transport

 ISBN: 978-93-90214-19-8

behaviour drastically. Bed configurations in mountain rivers are much more complex than in plain rivers, owing to steep slopes, poorly sorted surface grains [1], [2], wide grain size distributions, heterogeneity in bed topography, large and immobile boulders, pebble clusters, etc. [3]. Soil characteristics of the bed and channel boundaries are vital and the large variation in the bed sediment size, often ranging from Boulders to Sand, can also affect the sediment transport behaviour of the stream. The cross-section of the stream is narrowed by the boulders and acceleration is induced to flow around boulders with remarkable reduction of flow velocity at the upstream of the boulders [4]-[6].

The measurement of field quantities can help in finding the suitable empirical equation for a study area from the available existing bed load equations. The bed load equations were mostly developed on the basis of experimental observations and have been found to overpredict by order of magnitude when tested for natural rivers [7], [8]. A possible reason of overprediction by such equations can be assumption of constant value of critical shear stress for grain entrainment, but measured values can vary by almost an order of magnitude between rivers. [9]. Besides knowing the bed load transport rate, the field measurements also indicate the nature of bed load in terms of sediment characteristics, primarily size. Bed load with different sizes can be grouped into two types: travelling bed load and structural bed load. Travelling bed load is composed of sediment finer than a critical size, Dc, and its transport rate depends mainly on the incoming sediment rate. The transport rate of traveling bed load (D < Dc) can vary significantly, depending on the incoming rate of sediment; while the rate of structural bed load transport depends mainly on water flow [10].

II. STUDY AREA

The Ambica river basin is selected as study area as it provides an ideal combination of gravel and sand bed composition during different stages of its course. The river originates in Saputara and flows down to meet Arabian Sea.

Ambica River has its basin area of 2715 km2 in Gujarat and Maharashtra. The basin lies between 20° 31' - 20° 57' N latitude and 72° 48'-73° 52' E longitude. It is one of the biggest west flowing rivers. It is divided into two zones. The eastern part consists of rugged mountain chain of Sahyadri Western Ghasts with the elevations ranging from 1050 m to 100 m. The western part consists of hills and valleys which are having elevations less than 100 m. It originates from Saputara Hills. It drains in to Arabian Sea after flowing for the approximate length of 136 km. Kapri, Wallan, Kaveri and Kharera are the important tributaries of the Ambica River. The basin map of Ambica River is shown in Figure 1.

Fig 1. Study Area (Kharera River-Ambica Basin)

(Source: http://www.india-wris.nrsc.gov.in/wrpinfo/images/d/d2/Ambica_basin.png)

The stream bed consists of sand, gravel and cobble. The basin is largely forested with the sparse shrubs. The stream has been selected for the collection of the sample data because of the flow depth of about 0.2 - 0.8 m and the width of the stream at the stream was well defined at the time of monsoon period.

III. FIELD MEASUREMENTS

Field measurements were carried out at the study area during monsoon season at three cross sections at 3, 8 and 13 m distance from Right Bank of river (Fig. 2). Fig. 3 shows the flow conditions of high flow during monsoon. The measurements were performed using standard field equipments like Dumpy level (cross section measurement), current-meter (velocity) and modified Helley Smith Sampler (bed load sampling) (Fig. 4). The collected samples were processed in the laboratory subsequently. The collected samples were oven dried and then sieved using standard sieves to obtain gradation of the bed load.

Fig 2. Cross-sections for sampling

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Fig 3. Flow conditions during monsoon

Fig 4. Cross-section measurements at site during monsoon flow

IV. Summary of Measured Hydraulic and Sediment Data

During the **monsoon** and sufficient flow conditions, the depth and velocity were measured using current meter at the section-A, B, C. The bed load samples were collected using modified H-S sampler. The numbers of points across the section were taken as 3 due to multiple simultaneous data collection and the short period of flow.

The longitudinal slope and cross-section levels were measured before and during the sampling. The flow depth (d) and velocity at 0.2d, 0.6d & 0.8d were measured at each sampling**.** The summary of data collected during the monsoon 2019 is given in Table 1 and the range of Hydraulic data is given in Table 2.

Table 1. Summary of Samples collected during Monsoon

S. No.	Section (Longitudinal)	Lateral Points	Helley Smith Samples
1	A	3	4
		8	5
		13	7
2	B	3	2
		8	3
		13	4
3	C	3	3
		8	2
		13	4

Table 2. Range of hydraulic data collected from field sampling during Monsoon

S. No.	Observed Parameter	Range		
		Min.	Avg.	Max.
1	Flow Depth (m)	0.10	0.406	0.85
2	Mean Velocity (m/s)	0.0719	0.5226	1.1867
3	Discharge (m^3/s)	0.0363	1.2020	4.0283
4.	Median Sediment Size (HS) D_{50}, mm	0	3.539	10.97
5.	Bed Load Transport Rate (g/ms) (HS)	0	1.2689	6.0951

The bed load samples collected from HS sampler show similar composition and have sediments falling in categories of Coarse sand to pebble (0.5-16.0 mm).

Table 3 presents the Grain Size Distribution (GSD) of a sample (R1S2) of bed load measured using HS sampler at site. The plot of GSD is shown in Fig. 5.

Table 3. Grain Size Distribution of a Bed Load Sample using HS Sampler

R1S2				
Sieve size(mm)	weight retained (gm)	% weight retained	Cumulative % weight retained	% finer
20	0	0	0	100
10	12	11.764	11.764	88.235
4.75	14	13.725	25.490	74.509
2.36	11	10.784	36.274	63.725
1.18	29.5	28.921	65.196	34.803
0.5	27	26.470	91.666	8.333
0.3	8.5	8.333	100	0
0.15	0	0	100	0
0.075	0	0	100	0
Total Weight -	102			

 ISBN: 978-93-90214-19-8

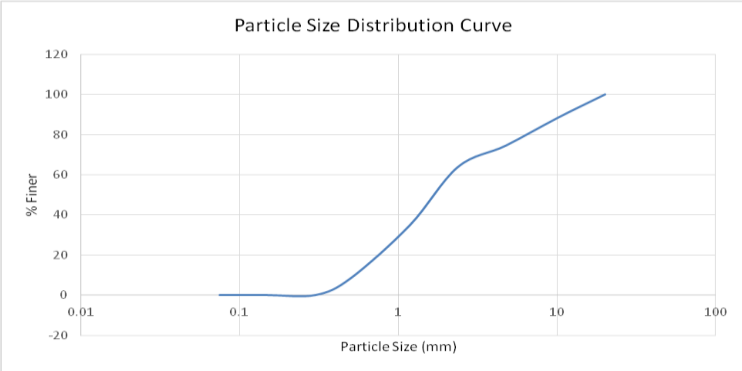

Fig 5. GSD Curve for the Bed Load sample R1S2 by HS Sampler

The GSD curves were plotted for all the bed load samples and various sediment sizes, like d50, d10, d60, etc. were calculated. A sample of observed sediment sizes are shown in Table 4 and the Table 5 shows the sediment size at different laterals of the sections corresponding to the flow rate.

Table 4. Different sediment size (mm) for samples of HS sampler at 13 m from right bank

SAMPLE ID	D10	D16	D30	D35	D50	D60	D80	D84
R1S3	1.42	1.71	2.40	2.81	4.046	4.96	7.93	8.532
R2S3	0.73	0.98	1.79	2.12	4.152	5.98	9.84	11.876
R3S3	0.48	0.60	0.91	1.01	1.521	1.97	5.20	6.167
R4S3	1.35	1.81	4.51	6.35	10.972	12.7	16.3	17.11
R5S3	0.94	1.32	2.13	2.53	4.729	6.43	9.84	11.628
R6S3	0.60	0.87	1.63	1.95	3.668	5.32	9.49	10.886
R7S3	0.84	1.04	1.62	1.84	2.758	3.95	6.85	7.48
R8S3	0.67	0.89	1.53	1.81	3.555	5.93	12.3	14.866
R9S3	1.01	1.34	2.00	2.24	3.794	5.03	8.39	9.062
R10S3	0.41	0.48	0.80	0.91	1.376	1.92	7.76	10.568
R11S3	0.87	1.09	1.56	1.72	2.212	3.07	6.15	6.92
R12S1	1.31	1.65	2.54	3.07	4.67	6.18	9.27	9.893
R12S2	0.63	0.98	1.91	2.25	4.218	6.15	12.6	16.133
R12S3	0.56	0.74	1.15	1.82	4.152	5.45	7.72	8.18
R13S3	0.80	1.09	1.71	1.92	2.964	4.13	9.30	10.987

Table 5. Median Size of sediment for Bed Load measurements by HS

S. No.	Distance from right Bank	Sample ID	Bed Load Transport Rate (g/ms)	Median Diameter, D50 (mm)	Segmental Discharge (m3/s)
1	3	R1S1	0.0273	1.77	0.273
2	3	R2S1	0.6671	5.21	0.225
3	3	R3S1	0.4593	1.08	0.574
4	3	R4S1	0.0000	5.92	0.547
5	3	R5S1	1.1155	2.84	0.689

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6	3	R6S1	0.6671	4.03	0.451
		Avg.	0.4894	3.4739	0.460
1	8	R1S2	0.4703	1.80	0.659
2	8	R2S2	0.1312	2.34	0.494
3	8	R3S2	0.2187	1.67	1.267
4	8	R4S2	0.1750	8.33	1.075
5	8	R5S2	1.4162	9.67	1.109
6	8	R6S2	0.2351	5.07	0.970
7	8	R9S2	0.7218	3.56	0.316
		Avg.	0.4812	4.6328	0.841
1	13	R2S3	1.3233	4.15	1.947
2	13	R3S3	0.0000	1.52	0.963
3	13	R4S3	0.0000	10.97	1.162
4	13	R5S3	0.6999	4.73	1.475
5	13	R6S3	0.9077	3.67	0.903
6	13	R8S3	1.2467	3.56	2.116
7	13	R9S3	0.3992	3.79	1.993
8	13	R12S1	3.2663	4.67	1.199
		Avg.	0.9804	4.6334	1.470
	Overall Average				0.924

A rating curve between segmental discharge and bed load transport rate was plotted (Fig. 6) to obtain the degree of correlation. The equation obtained can be used to predict the bed load transport rate for a given discharge.

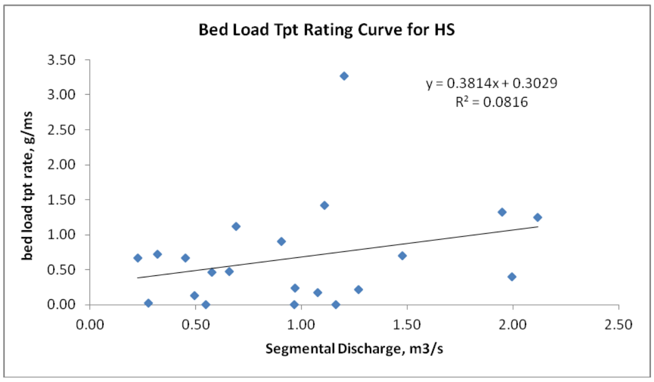

Fig. 6. Rating curve for bed load transport rate

Flow competence curves were plotted for the observed discharge and the median size moved as bed load. A sample curve for 13 m longitude is shown in Fig. 7.

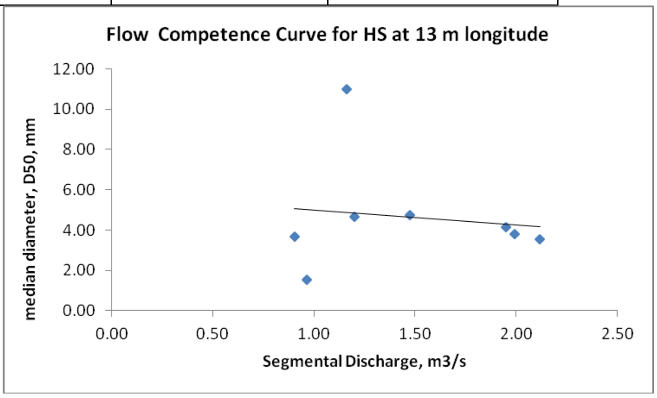

Fig. 7. Flow competence curve for 13 m longitude

It can be observed that for the same discharge the different sediment size can move depending on prevailing hydraulic conditions.

V. Bed Load Transport Analysis & Results

The prediction of bed load transport rate using different equations proposed by Einstein (1950) and Schoklitsch (1950) was carried out. The predicted bed load transport rate was compared with measured bed load transport rate and the most significant statistical parameter, Discrepancy Ratio (DR) was used to assess the performance of the bed load equations.

The bed load function developed by Einstein (1950) is derived from the concept of probabilities of particle motion.

According to Einstein the bed load transport was related to fluctuation rather than the average values of all the forces that flow exert on the sediments particles. He considered bed load as the transport of sediments in a thin layer of two particle diameter thickness just above the bed. These grains move by saltation as of the fluctuation lift force and then perform a jump with a longitudinal distance of about 100 particles diameter. The jump length was related to sediment size and was assumed to be independent of hydraulic conditions.

Einstein's relations contain all pertinent variables of water and sediment transport, however, the data used in the calibration was obtained only from laboratory experiments, the method has not provided satisfactory accuracy in most practical engineering projects. The bed load functions is given as (1)

$$1-\frac{1}{\pi}\int_{-B_*\varphi_*-{}^{1}/_{n_o}}^{B_*\varphi_*-{}^{1}/_{n_o}} e^{-t^2}\,dt=\frac{A_*\phi_*}{1+A_*\phi_*} \qquad (1)$$

Where ϕ_*= intensity of sediment transport

A_*, B_* and n_o are universal constant to be determined from experimental data.

The performance of bed load equations for the measured bed load data is assessed using the most potent statistical measure, Discrepancy Ratio.

The comparison of performance of selected bed load equations is given in Table 6.

From Table 6, it is observed that the tested discharge base bed load transport equations Schoklitsch (1950) fails to predict for the measured river data. Improvement in prediction is obtained with increase in discharge as shown in yellow colour. However similar trend of prediction is not observed in case of high peak discharge as indicated with pink colour. Thus it is difficult to say that discharge alone plays a significant role in sediment transport. It is also observed that the tested Probabilistic bed load transport equations, Einstein (1950) predicts well for sediment of coarse sand size for the present range of hydraulic parameters.

CONCLUSION

Following conclusions can be made from the field study and analysis of observed measurements:

1. The flow velocity changes considerably with respect to time as the river gets flow due to rainfall in the upper catchment.

Table 6. DR for predicted bed load transport rate

DR for Bed Load Transport Equations			Hydraulic Parameters	
Sample ID	**Schoklitsch (1950)**	**Einstein (1950)**	**Sediment size, m**	**Slope**
R1S1	-209.26	6.78	0.0018	0.0014
R2S1	-13.10	0.00	0.0052	0.0014
R3S1	179.31	7.07	0.0011	0.0014
R4S1	-60.60	0.01	0.0059	0.0014
R5S1	56.02	4.69	0.0028	0.0014
R6S1	-13.60	0.30	0.0040	0.0014
R7S1	314.98	6.42	0.0022	0.0014
R8S1	-15.23	0.20	0.0009	0.0014
R11S1	31.72	2.76	0.0020	0.0014
R1S2	34.33	0.88	0.0018	0.0021
R2S2	11.13	0.69	0.0023	0.0021
R3S2	125.19	4.14	0.0017	0.0021
R4S2	3.53	0.06	0.0083	0.0021
R5S2	-162.17	0.91	0.0097	0.0021
R6S2	45.70	1.24	0.0051	0.0021
R7S2	834.03	21.09	0.0028	0.0021
R8S2	-12.06	0.00	0.0074	0.0021
R9S2	-206.10	0.58	0.0036	0.0021
R10S2	23.93	0.13	0.0079	0.0021
R13S2	126.88	9.50	0.0006	0.0021
R1S3	1.73	0.05	0.0040	0.0009
R2S3	26.48	0.10	0.0042	0.0009
R3S3	32.96	1.37	0.0015	0.0009
R4S3	-261.12	0.00	0.0110	0.0009
R5S3	1.03	0.02	0.0047	0.0009
R6S3	-1.05	0.18	0.0037	0.0009
R7S3	11.40	0.05	0.0046	0.0009
R8S3	33.13	0.06	0.0036	0.0009
R9S3	17.31	0.04	0.0038	0.0009
R10S3	9.77	0.18	0.0014	0.0009
R11S3	29.82	1.52	0.0022	0.0009
R12S1	-3.17	0.00	0.0047	0.0009
R12S2	-0.54	0.02	0.0042	0.0009
R12S3	10.25	0.05	0.0042	0.0009
R13S3	4.44	0.06	0.0030	0.0009

2. Highest bed load rate (measured by HS sampler) was observed at 13 m lateral at section A. No bed load movement took place for small velocity of flow.
3. High quantity of bed load is measured even for low velocity conditions indicating the flow of sediment from upper catchment or severe bed erosion from upstream during the monsoon day.
4. The average d_{50} size observed in HS bed load samples at 3, 8 and 13 m from right bank are 2.163 mm, 4.588 mm and 3.893 mm respectively. **Overall average d_{50} size is 3.539 mm**.

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5. Sediments flowing as bed load falls in the sediment classification range of coarse sand to pebbles (0.5-16.0 mm)
6. Large variations in bed load rate are observed at different longitudes across the sections with respect to flow discharge rate.

7. For the same discharge values, the biggest size that can be moved varies much, indicating other parameters dominance in bed load transport.

REFERENCES

[1]. Rickenmann, D. (2001) Comparison of bed load transport in torrents and gravel bed streams. Water Resources Research 37 (12), 3295–3305.

[2]. Papanicolaou, A. N., Bdour, A. & Wicklein, E. (2004) One-dimensional hydrodynamic/sediment transport model applicable to steep mountain streams. Journal of Hydraulic Research 42 (4), 357–375.

[3]. Xu Zexing, Zhang Chenling, Yao Qiang, Wang Xiekang and Yan Xufeng (2019). Hydrodynamics and bed morphological characteristics around a boulder in a gravel stream, Water Supply, In Press.

[4]. Papanicolaou, A. N., Kramer, C. M., Tsakiris, A. G., Stoesser, T. Bomminayuni, S. & Chen, Z. (2012) Effects of a fully submerged boulder within a boulder array on the mean and turbulent flow fields: implications to bedload transport. Acta Geophysica 60 (6), 1502–1546.

[5]. Baki, A. B. M., Zhu, D. Z. & Rajaratnam, N. (2014) Mean flow characteristics in a rock-ramp-type fish pass. Journal of Hydraulic Engineering 140 (2), 156–168.

[6]. Baki, A. B. M., Zhu, D. Z. & Rajaratnam, N. (2015) Turbulence characteristics in a rock-ramp-type fish pass. Journal of Hydraulic Engineering 141 (2), 04014075.

[7]. Daniel Vázquez-Tarrío, Rosana Menéndez-Duarte (2015), "Assessment of bedload equations using data obtained with tracers in two coarse-bed mountain streams (Narcea River basin, NW Spain)", Geomorphology, Volume 238, 1 June 2015, 78-93

[8]. Yager, E. M., J. M. Turowski, D. Rickenman, and B. W. McArdell (2012). "Sediment supply, grain protrusion, and bedload transport in mountain streams", Geophysical Research Letters, 39, L10402, doi:10.1029/2012GL051654.

[9]. Guo-an YU1, Zhao-yin Wang (2009) "Effect of incoming sediment on the transport rate of bed load in mountain streams", International Journal of Sediment Research, 24, 260-273.

[10]. Yager, E. M., Schmeeckle, M. W., & Badoux, A. (2018). "Resistance is not futile: Grain resistance controls on observed critical Shields stress variations". Journal of Geophysical Research: Earth Surface, 123, 3308–3322. https://doi.org/10.1029/2018JF004817

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ISBN: 978-93-90214-19-8

Performance Study of Concrete Properties produced using treated wastewater

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Abstract - This Study emphasizes to use treated wastewater as a mixing water in concrete for sustainable development. Rapid industrialization and huge population increased demand of potable water. Due to scarcity of water it is necessary to use wastewater as a mixing water in concrete. In this experimental study we have taken three treated wastewater sample from different wastewater treatment plant of Nagpur region and these sample used for casting concrete cubes and cylinders .These cubes and cylinders were tested after 7, 28,90 and 180 days curing. Test result shows that the ratio of compressive strength of concrete made with treated wastewater to the compressive strength made with potable water was more than 90%.This study shows that treated wastewater may be the alternative to potable water for producing concrete.

Keywords: Concrete, Mixing water, Treated Wastewater, Compressive strength

INTRODUCTION

Water is the most precious thing available on the earth. We cannot think human life without water. In many parts of India, scarcity of drinking water is the major problem, at the same water is also essential part in construction activity. Generally it is assumed that water which is fit for drinking can be used in concrete, but due to huge scarcity of potable water, it is need of era to think about alternative to potable water .In this experimental study we have try to find out alternative to potable water for construction activity by using treated waste water.

According to the research conducted by Vijay H.The scarcity of water is becoming critical environmental issue all over the world. Any effort targeted at conservation of this limited resources, preventing environmental degradation and thereby reducing water shortage, is worthwhile. This research therefore focused on the reuse of treated waste water effluent in place of potable water in plain concrete production. The effect of physio-chemical characteristics of this non-fresh water on concrete strength were studied over time. From this study it is believed that the recommended reuse of wastewater in plain concrete works will indirectly conserve the scare water resources of the study area, as the regular sources would be concentrated on supply of drinking and other potable water usage.

P.Rama Mohan Rao and S.M.K.Moinuddin focuses on the usage of treated wastewater in the production of concrete so that the shortage and cost using potable water can be greatly reduced .In this paper it is chosen treated wastewater ,which give us the exact idea of corrosion and for the construction as well as strength and durability properties of the concrete .To determine the mechanical properties of concrete cast cube specimens using M 20 grade concrete with potable and treated wastewater .Water absorption test in order to determine the difference in absorption capacity. The other tests, which are conducted include Rapid Chloride Penetration Test,Sulphate and Chloride test are conducted on potable as well as treated wastewater at 7,14,and 28 days. Concrete cast with treated wastewater attained more compressive strength when compared with concrete cast with potable water and the chloride permeability is high for treated wastewater concrete compared to potable water concrete.

P.Puspalata and V.Divyasri represent the experimental investigation of finding the feasibility of using treated effluent as a agent in concrete mix. This scope of study is restricted to only plain concrete cement without reinforcement .Brackish water collected from residential building is effectively treated in treatment plants. The main objective of this project is to control the abundant use of drinking water in construction activities by implementing treated sewage effluent as mixing agent in concrete mix. This treated effluent can be directly used in concrete mix when it satisfies standards .Water sample of treated wastewater is collected and tested and analyzed along with chemical parameters were within the ASTM standards limits and can be used satisfactorily in concrete mixing .By using treated effluents in place of fresh water, not only saved natural resources but also enhanced the compressive strength of concrete up to 0.97%, 0.05%, 0.40% at curing ages of 7, 14.and 28 days.

The prime objective of this study was to check the feasibility of treated wastewater collected from different treatment plant from various part of Nagpur in the production of concrete.

MATERIAL AND METHOD

Cement –Cement is binding material used for construction that sets, hardens and adheres to other materials to bind them together. IN our experimental work we have used Ordinary Portland cement (53 grade) manufactured by Ultratech cement company having specific gravity of 3.15 g/m3.

Aggregates – Coarse aggregates of size 10 mm and 20 mm are collected from around Nagpur city area .Fine aggregates are collected from bank of river in nearby area of Nagpur. The specific gravity of coarse and fine aggregates was 2.72 and 2.64 with 0.5% and 0.77% water absorption respectively. The fineness modulus of coarse aggregates was 4.76 and for fine aggregates it was 2.99

Treated Wastewater – Treated wastewater (TWW) used in this experimental study were collected from three different wastewater treatment plant of Nagpur City area. All types' of treated wastewater along with potable water were chemically analyzed in the Hydrology Project Division, Water Quality Lab for different parameter. Observed results of different parameters of each type of treated wastewater are shown Table 1

Table- 1Water Quality Result

Parameter	TWW1	TWW2	TWW3	Potable water	Permissible limit(mg/l)
pH	7.35	7.47	7.51	7.9	6.5 To 8.5
Chlori de content	62.64	72.75	80.45	250	1000 Max
Sulphate content	74	78	86	200	400 Max
Alkalinity	480	492	510	280	600 Max
Total Dissolved Solids	798.2	851.5	934.8	250	2000 Max
Total Solids	864.6	857.4	938.5	250	-----

Water quality analysis of treated wastewater showed that all parameters are within permissible limit (IS 10500-2012)

EXPERIMENTAL INVESTIGATION

Concrete mixes were produced using different types of treated wastewater along with potable water. The water cement ratio was maintained for all types of concrete mixes .Concrete cubes specimen of size 150 x150x150 mm and cylindrical specimen of size 150 mm diameter and length of 300 mm were casted .Cubes and Cylinder specimens were casted using each types treated wastewater sample .Specimens were tested at different age period for finding out average compressive strength. A mechanical mixture was utilized for the mixing of concrete .The slump test was carried out for all mixes and slump found in the range of 85-110 mm.

Table 2 Compressive strength of cubes in N/mm2

Age of Concrete	***TWW1***	***TWW2***	***TWW3***	***Potable Water***
7days	***26.75***	***25.90***	***24.65***	***21.70***
28 days	***28.62***	***28.10***	***27.10***	***26.50***
90days	***29.97***	***31.95***	***31.20***	***33.15***
180 days	***30.05***	***32.10***	***3290.***	***35.95***

ISBN: 978-93-90214-19-8

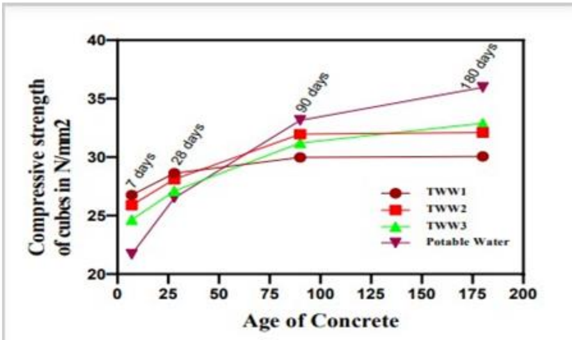

Figure 1 Compressive strength of all type of TWW w.r.t potable water at the testing ages of 7.28.90 and 180 days

After comparing the compressive strength of all types of mixing treated wastewater with potable water, it was found that all types of mixing water are suitable for concrete mixing and curing. Concrete mixed and cured using all types of treated wastewater are acceptable as compressive strength exceed 90% of that of potable water at age of 28 days.

CONCLUSIONS

The water quality analysis of treated wastewater for different parameters proves that treated wastewater can be used as mixing water in concrete

The properties of cement (initial and final setting time) mixed using treated waste water are within IS limit.

The compressive strength of concrete mixed and cured by all three types of treated wastewater are acceptable as they exceed 90

% of that of potable water at age of 28 days.

Experimental study shows that treated wastewater can be best alternative to potable water in concrete production.

Further durability test are required to find out durability properties in details.

REFERENCES

[1] Vijay H," Reusing Effluents for making concrete"Internatinal Journal of latest Technology in Engineering ,Management and Applied Science ,Volume VI, Issue 1,January 2017,

[2] P.Rama Mohan Rao,S.M.K.Moinduddin and Jagdish "Effect of Treated wastewater on the Properties of Hardened Concrete., ,Internatinal Journal of Science Volume 12(2014) ,155-162

[3] P.Puspalata and V.Divyasri "Behavior of concrete with Treated Sewage water "International Journal of Technical Innovation in Modern Engineering and Science, Volume 5 Issue 6,(2019)

[4] 4.K.S.AL Jabri,A.H.AL-Saidy.R.Taha,"Effect of using Wastewater on properties of High strength concrete" The Twelfth East Asia –Pacific Conference on Structural Engineering and Construction, Volume 14(2011).370-376

[5] Vidya Lakshmi, A.Arul Gideon "Secondary Treated Waste water in construction "International Journal of Science and Research (2013)

[6] Micheal M.Farouk ,Mohammed H.Hegazy,"Effect of using secondary Treated Wastewater in Production and curing of concrete"J.Mater Environmental Science ,Volume 11(2020) 1493-1502

[7] 7.H.EL-Ghorab , M.EL-Hossieny,M.S.Ibrahim and m.Kohail,"Effect of using Treated Wastewater in mixing and curing of concrete on its compressive strength"AL-Azhar University Civil Engg.Research Magazine ,Volume 41(2019) ,227-233

[8] Ali Raza,Sayyed Adnan Rahil Shah,Syed Noman Hussain Kazmi and Atif Mahmood ,"Performance Evaluation of Concrete developed using various types of wastewater: A step towards sustainability " Construction and Building Material"(2020) 1-10

[9] R.Mohanpriya, C.Mohansundaram and S.Sankar," Comparative study on effect of concrte made with Textile Effluent and ordinary Water" South Asian Journal of Applied Sciences, Volume 1 (2015) 28-31

[10] Manjunatha.M, Mr. Dhanraj M R "An Experimental Study on Reuse of Treated Waste Water in Concrete – A Sustainable Approach" International Journal of Latest Engineering Research and Applications (IJLERA) Volume – 02, Issue – 07, (2017), 124-132

[11] Micheal M. Farouk, Mohamed H. Hegazy "Effect of using secondary treated

wastewater in production and curing of concrete" J. Mater. Environ. Sci., Volume 11, (2020), 1493-1502

[12] Marcia Silva and Tarun R. Naik "Sustainable Use of Resources – Recycling of Sewage Treatment Plant Water in Concrete", Vol. 9 Issue 02, (2020)

[13] Jamuna M, Ramadevi K, Madhumitha P, Gokul Mohandas V, Satheesh T "A Research on the Effect of Treated Grey Water on Workability and Strength of Plain concrete" International Journal of Engineering and Advanced Technology, Volume-8, , (2019)

[14] Hummaira Kanwal,Sabahat Arif and Muhhamad Arif Khan " Effect on Compressive Strength of Concrete using Treated Wastewater for Mixing and Curing of Concrete " Volume 37 (2018) ,445-452

Behavior of CFRP Confined Concrete Under Different Temperatures

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Abstract - Carbon fiber reinforced polymer (CFRP) confining is tending as a modern technique for repairing and rehabilitating concrete and steel structures. CFRP sheets and laminates are light in weight and high strength in tensile properties, like long-term durability in severe environmental conditions. In this study concrete is undergone for elevated temperatures for 100^{0}C, 200^{0}C, 300^{0}C, 400^{0}C. Concrete cylinders 150mm*300mm size are prepared and used for the experiment. CFRP sheets are confined on the concrete surface after the concrete is exposed for all 100^{0}C, 200^{0}C, 300^{0}C, 400^{0}C different temperatures then confined with CFRP sheet. Experimental results show that concrete specimens show strength reduction and spalling of the concrete surface at 400^{0}C. Confined specimens with CFRP is shown increment in strength for all temperature-affected concrete specimens. In this study, concrete specimens obtain strength by CFRP sheet confining even after effected in elevated temperatures upto 300^{0}C.

Keywords: Concrete, CFRP, Carbon Fiber Reinforced Polymer, Confining, Temperature

INTRODUCTION

Carbon-fiber-reinforced polymer (CFRP) is one of the popular techniques for the repair and rehabilitation of concrete and steel structural components to increase their axial, shear strength, and seismic resistance. The CFRP sheets are wrapped around the columns in the circumferential direction. The fiber sheet confines around the concrete cylinder increase the axial strength by creating a triaxial stress condition. The FRP wrapping prevents premature spalling failures and increases the shear resistance of columns when columns are subjected to lateral loadings [1]. Moreover, fire safety assessment problems of structural fire resistance have recently become important. Concrete's fire resistance capacity is very complicated because not only is concrete a composite material with components having different thermal characteristics [2], Carbon fibers have very good thermal stability [3]. However, the epoxy adhesive used in externally-bonded FRP applications is very sensitive to temperature.

Exposure to elevated temperatures will lead to rapid and severe deterioration of the FRP/concrete bond, resulting in the FRP sheet's delamination and loss of its effectiveness [4]. At positive temperatures, concrete, adhesive, and CFRP lamina do not exhibit significant variations in their mechanical properties up to the adhesive glass-transition temperature (around 60°C). The differing thermal expansion coefficients between CFRP and Concrete, –1.46.106 °C–1 for lamina with a high elastic modulus in the fiber direction, 0.30.106 °C–1 for that with a low elastic modulus, and 10.106 °C–1 for concrete create tangential stresses which, at varying temperatures, can cause cracking in the concrete [5]. The American & Euro code drafts give recommendations for determining the degradation of concrete strength about the maximal heating temperature. However, it is known that the concrete strength degradation also depends on several other factors. The kind of aggregate used, loading level during the healing period, concrete moisture content, temperature increase, and cooling rate also play a very important role. This paper investigates the fire endurance of preheated and post-heated FRP-strengthened concrete circular columns.

Experimental program

Materials

Concrete

Ordinary Portland cement is used for this experimental study. Mix proportions of concrete are done with locally available aggregates and river sand. The material properties are stated in table 1 after testing as per IS code. The mix design of concrete as per IS 10262:2019 of M35 mix proportion.

Carbon Fiber-reinforced plastic (CFRP)

A unidirectional CFRP sheet manufactured by a horseen company fig is used for the experiment. The tensile property, elastic modulus, thickness, ultimate strength of the CFRP fiber, and fiber modules are denoted in table 1&2.

Epoxy resin

"Sikadur® -330 (IN)" is the two-part thixotropic epoxy-based impregnating resin used as the adhesive agent for wrapping CFRP fabric to concrete specimens. The technical specifications are shown in table 3&4.

Table 1: Typical Fiber Properties

S.No	Description	Value
01	Standard Value Of Tensile Strength	4.9kN/mm²
02	Tensile Elastic Modulus	234.5kN/mm²
03	Elongation	1.7%

Table 2: Laminate Fiber Typical Properties

S.No	Description	Value
01	Standard Value Of Tensile Strength	3.8kN/mm²
02	Tensile Elastic Modulus	34.5kN/mm²
03	Elongation	1.7%
04	Density	1.8g/cc
05	Nominal Fiber Thickness	0.128mm

Table 3: Technical Data

S.NO	Data	Description	
01	Chemical base	Epoxy resin	
02	Density	1. 3 kg/l A + 0.1 kg/l B (mixed) (at +30°C)	
03	Viscosity	Temperature	Viscosity
		+30°C	~ 38.0 Kg/m-s
04	Thermal Expansion Coefficient	4.5 x 10 -5 per °C (-10°C to +40°C)	

Table 4: Mechanical / Physical properties

S.NO	Property		Description (7 days at 23°C to +30°C)
01	Tensile strength		30 N/mm^2
02	E-Modulus	Flexural	2800 N/mm^2
		Tensile	3500 N/mm^2
03	Elongation at Break		0.9%

Specimen preparation

Forty-eight specimens are cast and retrofitted with CFRP were tested in this experimental program by an average of two specimens. The specimens were concrete cylinders with cross-sectional dimensions equal to 300mmx150mm. After casting and curing the concrete blocks, a 0.5mm surface was smoothened using sandpaper and then cleaned out with compressed air. The epoxy paste was prepared by mixing the epoxy Sikadur330 in a proportion of 4:1 by weight a homogenous paste without any streaks formed. The smoothened surface was then coated with the epoxy paste. Finally, specimens were left for 48 hours so that the resin could cure before Testing. The curing conditions were 28°C of temperature and 50% of relative humidity.

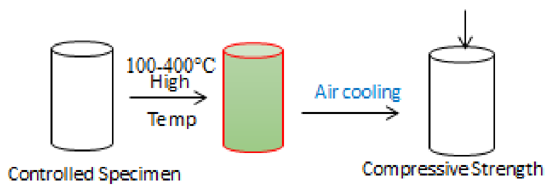
Test setup and Testing

The mix design of M35 grade concrete specimen per IS 10262:2009, caste and cured under ambient temperature 28days and been taken out left it to be dried at room temperature. Following IS 456-2019, standard concrete cylinders 150mm x 300mm were characterized by testing compressive strength of 28-day obtained 47.5 N/mm^2. Concrete cylinders are wrapped with CFRP around the cylinder 60.13 N/mm^2 compressive strength of specimens. To prepare concrete specimens, take sandpaper to smoothen the concrete's surface to avoid the CFRP sheet rupture. After smoothening the concrete surface, clean out the surface with compressed air. Epoxy resin is coated around the cylindrical specimen by the epoxy resin coating without air

ISBN: 978-93-90214-19-8

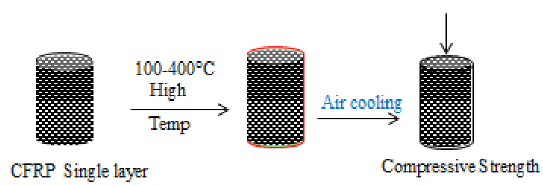
bubbles and patches on the surface. Take the CFRP sheet and cut-off the 300x150mm. A single coating of Epoxy resin is coated on one side of the sheet, wrapped on the concrete specimen, and then coat one more coating on the specimen's surface.
Tests are done after 48 hours of curing resin-coated specimens; the three series of wrappings are set out by different conditions 1.C-conventional concrete under thermal condition 2. RH-Conventional concrete Retrofitted with CFRP and tested after Heating.

1.C-conventional concrete under thermal condition



In this condition, the concrete specimens are treated under different that are100,200,300,400 degrees, thermal conditions that to be continued in the same at 1.5 hours continuously. After cooling the specimen at room temperature, tests are done.

2. RH-Conventional concrete Retrofitted with CFRP and tested after Heating.



The CFRP is wrapped before Testing and treated in 1.5 hours varied thermal conditions of 100,200,300,400 degrees and tested under to ultimate loading condition to observe ultimate load variations of those thermal variations.
Temperature Variations

Series	Specimen Id	Testing Temperature For 1.5 Hours	Relative Humidity@ Testing Time
C	C100A	100	50-55
	C200A	200	
	C300A	300	
	C400A	400	
RH	RH100A	100	50-58
	RH200A	200	
	RH300A	300	
	RH400A	400	

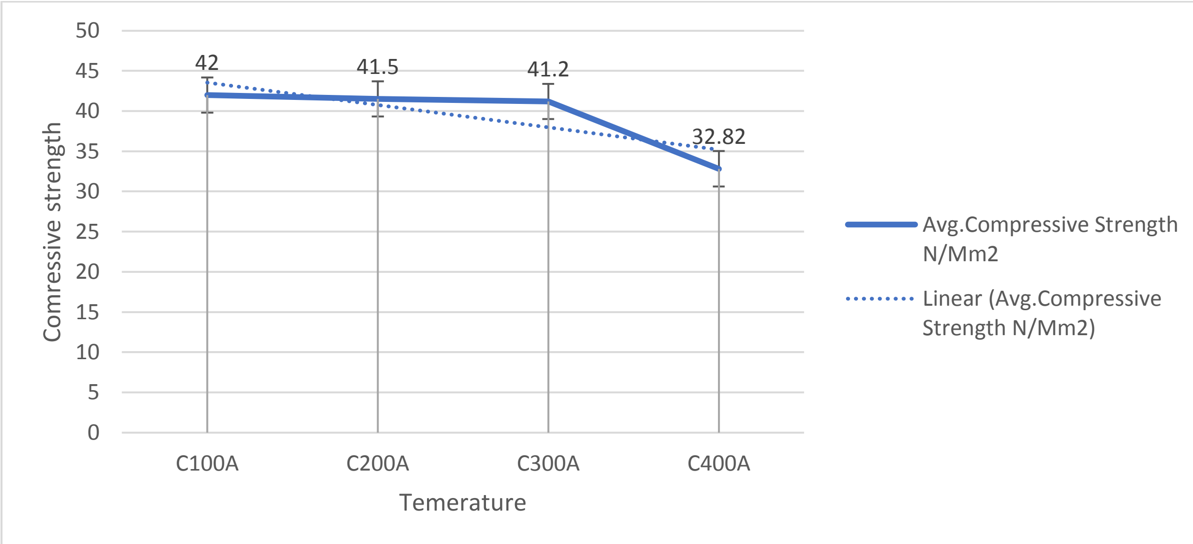
Experimental results and discussions

Compressive strength

Series	Specimen Id	Avg.Compressive Strength N/Mm^2
C	C100A	42.00
	C200A	41.50
	C300A	41.20
	C400A	32.82
RH	RH100A	58.01
	RH200A	57.54
	RH300A	46.74
	RH400A	36.90

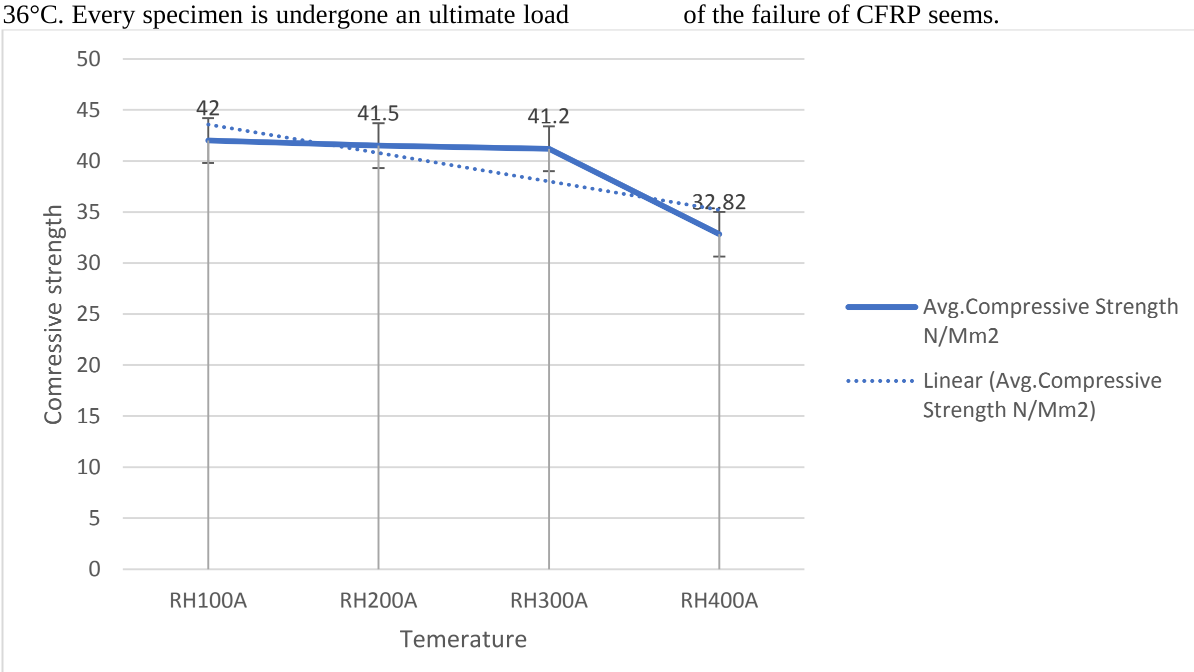
The result of all series are analyzed after testing of cylinders 28 water curing, CFRP wrapped specimens are wrapped in two ways that to be as follows,
1.C-conventional concrete under thermal condition
C-conventional concrete under thermal condition, the specimens are undergone to take the load as a conventional specimen. The thermally treated specimens are shown an increase in strength at the point of temperature 300 degrees. The ultimate load is decreased at 400 degrees. The observations are done when testing the concrete specimens are compressed at the static testing condition at every temperature range the initial failure of specimens is varied.

ISBN: 978-93-90214-19-8



2. RH-Conventional concrete Retrofitted with CFRP and tested after Heating.

RH-Conventional concrete Retrofitted with CFRP and tested after Heating. The specimens are tested after thermal treatment of CFRP by 100°C, 200°C, 300°C, 400°C at room temperature of 34°C-36°C. Every specimen is undergone an ultimate load test. Thus, the specimen behavior is observed at every temperature range at the temperature of 100°C. The CFRP Specimen failure is brittle at the peak load 200°C, 300°C, at 400°C, the CFRP is failed before the concrete specimen's failure. Noticed that the bond failure is seen at this part. The strength of the concrete specimens is increased up to 300°C at 400°C. The strength is decreased because of the failure of CFRP seems.



 ISBN: 978-93-90214-19-8

CONCLUSIONS

By testing all specimens at different temperatures and different conditions, the Concrete's main strength remains the same. Still, the increased strength of every specimen is by strength gain by CFRP, and the strength of the specimens is varied by temperature change.

Series C-conventional concrete under thermal conditions, the strength is varied by variation of temperature. Still, the specimen's strength is increased at 300°C and tends to slight down at 400°C. The spalling of Concrete is taking place by an increase of temperature.

Series RH-Conventional concrete Retrofitted with CFRP and tested after Heating, the strength of the concrete specimens is increased at the peak stage. The sudden change is seen at the temperature 400°C because the bond behavior of Concrete with CFRP is released out at the strength of 36.9 kN/mm^2.

REFERENCES

[1] M. Li, C. X. Qian, and W. Sun, "Mechanical properties of high-strength concrete after fire," *Cem. Concr. Res.*, vol. 34, no. 6, pp. 1001–1005, 2004.

[2] K. H. Tan and Y. Yao, "Fire Resistance of Reinforced Concrete Columns Subjected to 1-, 2-, and 3-Face Heating," *J. Struct. Eng.*, vol. 130, no. 11, pp. 1820–1828, 2004.

[3] J. C. P. H. Gamage, M. B. Wong, and R. Al-Mahadi, "Performance of CFRP strengthened concrete members under elevated temperatures," *Proceeding Int. Sysposium Bond Behav. FRP Struct. (BBFS 2005)*, no. Bbfs, pp. 113–118, 2005.

[4] M. F. Green, L. A. Bisby, A. Z. Fam, and V. K. R. Kodur, "FRP confined concrete columns: Behaviour under extreme conditions," *Cem. Concr. Compos.*, vol. 28, no. 10, pp. 928–937, 2006.

[5] L. C. Bank, *Composites for Construction: Structural Design with FRP Materials*. 2007.

[6] M. A. Youssef and M. Moftah, "General stress-strain relationship for concrete at elevated temperatures," *Eng. Struct.*, vol. 29, no. 10, pp. 2618–2634, 2007.

[7] E. U. E. Chowdhury, L. L. A. Bisby, M. F. Green, N. Bénichou, and V. K. R. Kodur, "Fire behaviour of FRP wrapped square reinforced concrete columns," *3rd Int. Conf. Durab. F. Appl. Fiber- Reinf. Polym. Compos. Constr.*, no. January, pp. 83–90, 2007.

[8] E. U. Chowdhury, L. A. Bisby, M. F. Green, and V. K. R. Kodur, "Investigation of insulated FRP-wrapped reinforced concrete columns in fire," *Fire Saf. J.*, vol. 42, no. 6–7, pp. 452–460, 2007.

[9] B. Das, S. K. Sahu, and B. C. Ray, "Effects of loading speed on the failure behaviour of FRP composites," *Aircr. Eng. Aerosp. Technol.*, vol. 79, no. 1, pp. 45–52, 2007.

[10] Y. A. Al-Salloum, H. M. Elsanadedy, and A. A. Abadel, "Behavior of FRP-confined concrete after high temperature exposure," *Constr. Build. Mater.*, vol. 25, no. 2, pp. 838–850, 2011.

[11] A. Ahmed and V. K. R. Kodur, "Effect of bond degradation on fire resistance of FRP-strengthened reinforced concrete beams," *Compos. Part B Eng.*, vol. 42, no. 2, pp. 226–237, 2011.

[12] R. H. Haddad, N. Al-Mekhlafy, and A. M. Ashteyat, "Repair of heat-damaged reinforced concrete slabs using fibrous composite materials," *Constr. Build. Mater.*, vol. 25, no. 3, pp. 1213–1221, 2011.

[13] Y. A. Al-Salloum, H. M. Elsanadedy, and A. A. Abadel, "Behavior of FRP-confined concrete after high temperature exposure," *Constr. Build. Mater.*, vol. 25, no. 2, pp. 838–850, 2011.

[14] H. Al-Nimry, R. Haddad, S. Afram, and M. Abdel-Halim, "Effectiveness of advanced composites in repairing heat-damaged RC columns," *Mater. Struct. Constr.*, vol. 46, no. 11, pp. 1843–1860, 2013.

[15] G. Ji, G. Li, and W. Alaywan, "A new fire resistant FRP for externally bonded concrete repair," *Constr. Build. Mater.*, vol. 42, pp. 87–96, 2013.

[16] M. Yaqub, C. G. Bailey, P. Nedwell, Q. U. Z. Khan, and I. Javed, "Strength and stiffness of post-heated columns repaired with ferrocement and fibre reinforced polymer jackets," *Compos. Part B Eng.*, vol. 44, no. 1, pp. 200–211, 2013.

[17] A. Roy, U. Sharma, and P. Bhargava, "Strengthening of Heat Damaged Reinforced Concrete Short Columns," *J. Struct. Fire Eng.*, vol. 5, no. 4, pp. 381–398, 2014.

[18] J. Zhu and Y. Wu, "Effect of exposure time and elevated temperature on ordinary concrete," *Emerg. Mater. Res.*, vol. 6, no. 1, pp. 178–183, 2016.

[19] ASTM E119-16a, "Standard Test Methods for Fire Tests of Building Construction and Materials, ASTM International, West Conshohocken, PA," vol. 552, no. 1, 2016.

[20] M. M. Rafi, T. Aziz, and S. H. Lodi, "Mechanical properties of low-strength concrete at exposure to elevated temperatures," *J. Struct. Fire Eng.*, vol. 8, no. 4, pp. 418–439, 2017.

[21] H. S. Al-Nimry and A. M. Ghanem, "FRP Confinement of Heat-Damaged Circular RC Columns," *Int. J. Concr. Struct. Mater.*, vol. 11, no. 1, pp. 115–133, 2017.

[22] *Durability of Building and Construction Sealants and Adhesives: 6th Volume*. 2018.

[23] M. Z. A. M. Zahid, B. H. A. Bakar, F. M. Nazri, M. M. Ahmad, and K. Muhamad, "Review of Repair Materials for Fire-Damaged Reinforced Concrete Structures," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 318, no. 1, 2018.

ISBN: 978-93-90214-19-8

Analysis of Structure with Floating Columns – A Literature Review

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Abstract - In recent times, multi-storey buildings in urban cities are required to have column free due to shortage of space, population and also for aesthetic and functional requirements. For this, buildings are provided with floating columns at one or more storey. The behavior of the building during earthquake depends on its overall shape, size and geometry and how the earthquake forces are carried to the ground. The earthquake forces developed in the building need to be transfered to the ground by the shortest path possible, any discontinuity in the path leads to the poor performance of the building.

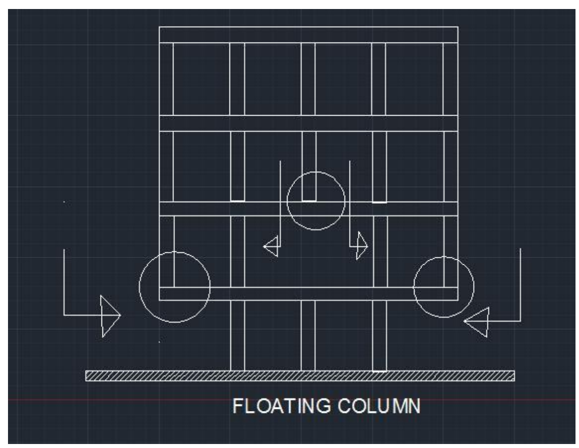
This paper gives an outline of the existing work that has been already carried out to study the response of the building in seismically active areas. A review of studies based on the behavior of building along with the results has been presented and from the studies it is found that buildings with the provision of floating columns increases space but are vulnerable and risky. So to ensure the safety and stability of the building the floating columns should be designed and placed properly according to the IS codal provisions.

Keywords: floating column, seismic, earthquake forces.

INTRODUCTION

In recent times, as a part of urbanization modern multi-storey buildings in urban cities are required to have column free due to shortage of space, population, for aesthetic purposes and functional requirements. For this, buildings with floating columns are provided at one or more storey. Provision of these floating columns in multi-storey buildings is highly disadvantageous in earthquake prone areas. The seismic forces developed in the building need to be transferred along the height to the ground by the shortest path available. Any interruption in this load transfer path leads to the bad performance of the building. The behavior of the building during earthquake depends upon its overall size, shape, geometry and how the earthquake forces are carried to the ground.

Floating Column: It is a vertical member which rests on a beam and doesn't have foundation. Floating columns acts as a point load on the beam and these beams transfer the load to the column below it.



LITERATURE REVIEW

A.P. Mundala et al (2014) this paper studied an existing G+7 residential building by equivalent static analysis for 3 models, building without floating columns, building with floating columns and building with floating columns and struts with load distributions on floating columns with various effects. The analysis was done using STAAD Pro V8i software and concluded that the possibility of failure with floating column is more than floating column with strut and deflection is much larger in case of floating column that floating column with strut.

Sreekanth Gandla Nanabala et al (2014) this paper studied a G+5 building with and without floating columns by applying intensities of the past earthquakes. The analysis was done by SAP 2000. The study is done to find floating column building is safe or unsafe and economical or uneconomical. Three models were prepared and the analysis is done by the Equivalent static analysis method and comparisons for the same were done based on displacement due to lateral loads, based on stiffness, based on quantity of steel and concrete, based on time history analysis and concluded that by the application of lateral loads in X and Y direction the deflections of the floating column building are less than normal building but large in Z direction so it is unsafe and the quantity of rebar and concrete required is more in floating column building and it is uneconomical.

Israa H. Nayel et al (2018) this paper analyzed a G+9 building with floating columns. The main objective of this study is to analyze different locations of shear walls in high rise buildings. Equivalent static analysis method was adopted to carry out the building analysis. Strength, stability and displacements of the buildings were taken into consideration. Models were made with different shapes of the shear walls and concluded that deflections and story drifts changed forcefully due to increase in height of the building and displacements is greater at top storey and lesser at the bottom storey and stiffness increased at first storey with shear wall in corner other than floating columns with shear walls and recommended to construct a building with shear wall at corner position.

Ayush Gupta et al (2020) analyzed regular G+4, G+10 and G+20 normal RCC frame buildings with floating columns in zone III by ETABS software and checked the models for storey displacements for floating columns placed at different locations by Equivalent Static Analysis and concluded that by eliminating circumference columns of the frame except the corner columns gives less displacement and also as we go higher in the building displacement increases.

Daparti Devi Prasanna et al (2017) This paper analyzed three buildings such as G+4, G+9 and G +14 located at zone III with and without floating columns by ETABS V15 software. Seven models were prepared such as building without floating columns, floating columns located at ground floor, floating columns with bracings at corner, floating columns with shear walls at corner, floating columns with bracings at peripheral sides, shear walls at center and shear walls at peripheral sides. The study adopted the use of Nepal Earthquake data and linear time history analysis. Storey drifts and lateral displacements were compared for all the models and concluded that the maximum displacement and storey drift values increased for floating columns. Axial forces increased in the columns other than floating columns due to transfer of loads from the floating columns to the conventional columns.

N. Elakkiyarajan et al (2018), In this study, a GF+ car parking+14+terrace residential building is analyzed using ETABS software with and without floating columns. The floating columns were placed at various locations. Due to floating columns strength of structure reduces and to strengthen, floating and respective beam below floating column various methods are adopted such as normal RCC s/c, steel s/c and composite s/c. dynamic analysis was adopted to obtain the design seismic force, and its distribution to different levels along the height of the building and concluded that steel s/c is more suitable for beams supporting floating columns. From deflection criteria concrete gives good results. For floating column, concrete model gives less value of bending moment than steel model. In case of shear force, steel gives better performance for zone II, III, IV. Also the demerit of providing floating column was sudden rise in shear force and bending moment at bottom storey.

Vyom Goel et al (2020), The purpose of this study is to analyze the behavior of floating column with flat slab and shear wall on the high rise building. A G+10 building under seismic forces was analyzed for moments and stresses using Staad pro and the main objective was to study high rise building with floating column under Earthquake excitations. Few models were prepared with and without floating columns with loads acting on the building and concluded that bending stresses are more in floating column structures than normal RCC structures. Direct stress values are more in shear wall with floating structures than normal RCC structures.

Mohd. Jamaluddin Danish (2017) In this study, an attempt was made to study the performance of multistorey reinforced concrete building frame due to provision of masonry infills and shear wall, eleven models were prepared for 15 storey each.

Eleven models with variation in dimensions and shapes in shear walls were analyzed by equivalent static method and response spectrum method using ETAB software and the comparison was done based on time period, story drift and story displacement by both ESA and RSA methods and concluded that the time period reduces when the effect of infill masonry wall and concrete shear wall is considered and by introducing shear walls storey displacement reduced by 50%.

Kirankumar Gaddad et al (2018) This study analyzed a G+20 storey building for four different models. First model of normal building, second model with floating column structure, third model with shear wall structure and fourth model with both shear walls and floating columns. The models were analyzed with both ESA and RSA for parameters like storey displacements, storey shear, storey drift and time period using ETABS and concluded that storey displacements comparing to model1, increased 6% in model II, decreased by 45% in model III, 40% in model IV. Time period of floating column building is greater than all four models and shear wall structure gives better performance, lesser displacements and more strength comparing to other models.

P.S. Dhajekar et al (2016) The work focused on behavior of structure with and without provision of floating column and the necessity to check whether the structure is safe or unsafe with floating columns in seismically active areas. The study is carried out on G+10 OMRF structure. ESA is carried out for earthquake zone III by STAAD Pro V8i S5 software. The results are compared based on performance of the buildings against lateral stiffness and concluded that shear walls are much efficient in reducing lateral displacements of structure.

Isha Rohilla et al, (2015), In this paper need of floating columns in highly populated areas is understood, the behavior and advantages of floating columns are discussed. Although the floating columns are not suitable for the earthquake active areas but it doesn't provide path to the earthquake forces to be carried down in the ground. Building of G+5 and G+7 for zone II and V having irregular architectural complexities is analyzed for this paper. The size and shape of beams and columns are also analyzed for the complex architecture. Etabs software is used to evaluate the parameters like store drift, storey displacement and storey shear and concluded that floating column building should be avoided in zone V because it leads to storey displacement and increasing the size of beams and columns can improve the strength of building with floating columns.

Priya Prasannan et al (2017) In this study, the effect of varying the location of floating columns floor wise and within the floor of multi-storied RC building on various structural response qualities of the building using RSA is studied by ETABS 2015. The main objective of the study was to study the seismic response of building with floating columns and to find out most suitable configuration for providing floating columns. Comparisons were made on parameters such as total base shear, displacement, drift of the building and concluded that time period and base shear is more with floating column provided at GF and shear walls provided at diagonal corners are most effective to resist lateral load.

Arpit Shrivastav et al (2018) The objective was to study the behavior of mutistorey buildings having floating columns under seismic forces and to observe effect of shear wall in the same. Three models were created with 8 storey, 12 storey and 16 storey and the models were considered having floating columns provided with and without shear walls in zone III, IV ,V by STAAD Pro. Observations showed that provision of floating columns is advantageous in increasing FSI but is also risky. From the analysis it is also observed that lateral displacement and storey drift increases from lower to higher zones and by using shear walls and also this work provided beneficial help on parameters lateral displacement and storey drift in multistorey buildings having floating columns with and without shear walls.

Y. Abhinay et al (2017) This study analyzed a residential building with 6 and 12 storeys with column, beams & slabs. The buildings were analyzed with static load combinations and RSA to compare results for the building designed with and without edge columns at base storey and concluded that floating column building is unsafe than normal building also it is uneconomical than normal building as the quantity of rebar steel and concrete required is more than the normal building.

Keerthi Gowda B.S et al (2014) This study examines the adverse effect of the floating columns in building. Models of frame are developed with and

ISBN: 978-93-90214-19-8

without floating columns to carry out comparative study of structural parameters such as natural period, base shear and horizontal displacement under seismic excitation and the results obtained depicts that the alternative measure of providing lateral bracing to decrease lateral deformation should be adopted and by providing lateral bracings seismic performance of the building increased upto 10% to 30%.

Pradeep D et al (2017) In this study, two models of buildings, building with and without floating column at different floor levels are studied and seismic parameters such as time period, base shear, story displacement, story drift are compared for both the models using ETABS software. The methods used for the analysis were linear static, linear dynamic and non-linear static and concluded that storey shear was maximum at 1st storey and decreased to minimum at top storey and buildings without floating columns showed 35% lesser displacement when compared with buildings with floating columns.

CONCLUSION

It is observed that buildings with floating columns increases space but are unsafe in seismically active areas.Buildings with floating columns are uneconomical.

It is observed that deflections are higher in buildings provided with floating columns than normal buildings.

Storey drift values are more in floating column building than normal building.

Buildings with floating columns have more time period and base shear when compared to normal building.

From the above literature review it is observed that, floating column building with shear walls, struts, bracings etc shows better results in seismically active areas.

REFERENCES

1) A.P. Mundala, S.P Sawdatkar(2014), "Comparative Seismic Analysis of Multi-storey Building with and without Floating Column", Research Article, Vol.4, NO.5, E-ISSN 2277-4106, P-ISSN 2347-5161, INPRESSCO,
2) Sreekanth Gandla Nanabala, Pradeep Kumar Ramancharla, Arunakanthi E (2014), "Seismic Analysis of Normal Building and Floating Column Building", Journal of Engineering Research and Technology(IJERT), Vol.3, Issue.9, ISSN:2278-0181,
3) Israa H. Nayel(2018), "The Effect of Shear Wall locations in RC Multi-storey Building with Floating Column subjected to Seismic load", IJCIET Vol.9, Issue 7, July 2018, pp.642-651, ISSN Print:0976-6308 and ISSN Online:0976-6316,
4) Aayush Gupta, Umesh Pendharikar(2020), "Multistorey Building with and without Floating Column", IJITEE, ISSN:2278-3075, Volume-9, Issue-4,
5) Daparti Devi Prasanna, T. Santhi Sagar(2017), "Seismic Analysis of Multi-storey Building with Floating Column", Volume No:4, Issue No:8, ISSN No:2348-4845,
6) N Elakkiyarajan, G Iyappan and A Naveen(2018), "Seismic Analysis of Multi-storey Building Floating Column", IOSRJEN, ISSN(e):2250-3021, ISSN(p): 2278-8719,
7) Vyom Goel, Mr. Ajith Kumar Jain(2020), "Seismic Analysis of Multi-storey Building with and without Floating Column and Shear Wall using STAAD Pro Software", International Journal of Advanced Science and Technology, Vol.29, No.8s, pp.4306-4318,
8) Mohd. Jamaluddin Danish(2017), "Seismic Analysis of Multi-storey Building with Infills Shear Wall having Floating Column", IJSRD, Vol.5, Issue 10, ISSN(online): 2321-0613,
9) Kirankumar Gaddad, Vinayak Vijapur(2018), "Comparative Study of Multi-storey Building with and without Floating Columns and Shear Walls, IRJET, Vol:05 ,Issue:07, July 2018, e-ISSN:2395-0056 p-ISSN:2395-0072,
10) P. S. Dhajekar, G.B.Bhaskar (2016), "Seismic Analysis of RCC Structure with Floating Column on Different Position", IJSRD, Vol.4, Issue 05, ISSN(online):2321-0613,
11) Isha Rohilla, S.M. Gupta, Babita Saini (2015), "Seismic Response of Multi-storey Irregular Building with Floating Column", International Research Journal of

Engineering and Technology, Vol:04, Issue: 03 March 2015, Pg.No.-506-518,

12) Priya Prasannan, Ancy Mathew, "Sesimic Response of RC Floatingg Column considering Different Configurations", IJERT, ISSN:2278-0181, Vol.6 Issue 05, May-2017,

13) Arpit Shrivastav, Aditi Patidar, "Seismic Analysis of Multistorey Buildings having Floating Columns", SSRG-IJCE, Vol.5, Issue 5- May 2018,

14) Y. Abhinay, Dr. H. Sudarsana Rao, Dr. Vaishali G. Ghorpade, "Comparison of Seismic Analysis of Floating Column Building and Normal Building", International Journal of Material Sciences, ISSN 0973-4589, Volume 12, No.3(2017), pp.421-431,

15) Keerthi Gowda B.S, Syed Tajodden, "Seismic Analysis of Multi-storey Building with Floating Columns",Conference paper-May 2014,

16) Pradeep D, Chethan V R, Ashwnin B T, "Seismic Analysis of Multi-storey Building with Floating Columns using ETABS", IJSDR, Vol.2, Issue 9, ISSN:2455-2631, Sept 2017.

17) IS 456:2000-Indian Standard-"Plain And Reinforced Concrete- Code Of Practice", Bureau of Indian Standards, New Delhi.

18) IS 1893 (Part 1) 2016- Indian Standard-"Criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi.

19) IS 456:2000-Indian Standard-"Plain And Reinforced Concrete- Code Of Practice", Bureau of Indian Standards, New Delhi.

20) IS 1893 (Part 1) 2016- Indian Standard-"Criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi.

"Review on Analysis & Design of Optimum Pipe Rack for Various Bays"

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Abstract— ***Pipe racks are most common structures in industries like Oil & Gas, Petrochemical, refinery, etc. It carries various pipes from one Equipment to another or from one unit to another unit. Pipe racks should be designed for various loads like essential loads and pipe loads. Different software are used for analysis of Pipe rack whichever is suitable. Members of Pipe racks can be designed by using Indian Standard, American Standard or British Standard codes as per requirement and location of the project but because Pipe racks are considered as non-building structures code referenced documents will usually not cover the design and analysis of the structure. Present study aims the study of Analysis and Optimum design of Pipe rack. As the majority of material involves, there will be cost impact on the project and hence optimization is required. The Members of the Pipe racks has to be suitable verified for Strength, Vertical and Horizontal Deflection. The overall drift limit of the Pipe racks has to be maintained within the desired limit.***

Index Terms— ***Pipe Rack, Non-Building Structures, Steel structure, cost effective, bracings.***

I. INTRODUCTION

Pipe networks are considered as main components of industrial complexes like refineries and petrochemicals that transfer fluid and gas. Pipe rack is concrete or steel structure (better fire resistant) which carries multiple pipes carrying liquid or gas in different tiers and also carries Electrical/Instrument/Telecom Cable trays for supporting Auxiliary Equipment like Air Coolers, Pressure release valves etc. with service platforms and walkways. Structural steel pipe racks support pipes, power cables and instrument cable trays. They also carry large diameter to small bore lines with liquid or gas from one Equipment to another Equipment or from one unit to another unit. These are necessary for carrying large number of Process lines, Utility lines, Flare lines etc. Pipe racks have a series of transverse bents which run along the length and are spaced at uniform intervals of the pipe system typically around 20 ft. The transverse bents are typically moment frames and connected with longitudinal struts for maintenance access.

There are different types of pipes on the pipe rack. Utility pipes which include steam, cooling water, extinguishing water, fuel oil, etc. They are mostly located in the middle of a one-level pipe rack or on the top level. Then there are the Process pipes. These pipes carry product that is part of the chemical reaction. These are placed on the outside of the utility pipes because of their heavy weight or on the bottom level when there are multiple levels. Lastly, relief and flare pipes which fulfil a safety goal. They are always located on the outside of the rack to protect the installation against too much pressure.

The pipe rack, as a complete structure system and its structural elements should perform their function adequately and safely, with appropriate degree of reliability during design life. It should withstand all actions, consisting applied and induced loads as well as environmental influences liable to occur, retaining its structural integrity, and also withstand accidental loads and earthquake loads without causing damages. Here the literature aims to review the various literatures for analysis and designing of combined pipe rack made with steel rack and R.C.C support which shall combine advantages of steel and concrete.

II. LITERATURE REVIEW

Many authors have reported the use of pipe rack in various civil engineering applications.

The paper titled **"Comparative Study of Pipe Rack Structure with Modular Concept and Normal Stick-built Approach using ASCE 7-02"** authored by **Ashit K. Kikani and Vijay R. Panchal.** After the comparison of Modular concept and Normal stick-built Approach, modular structure possesses extra steel than those of normal structure. Modular structure possesses heavier steel design, hence it is more economical. Due to the additional analysis of the structure during transportation phases deflections found in tiers at different level in normal pipe rack structure are comparatively less in values. Pipe rack loadings considered are Self weight, Pipe operating load, Pipe empty load, Cable tray operating load, Pipe friction loads, Pipe restraint / thermal anchor loads.

The paper titled **"Design and Analysis of Pipe Rack System using STAAD PRO V8i Software"** authored by **J. K. Sumanth and Dr. C. Sashidhar.** The paper aims to model pipe rack steel structure PR 18-01 and analyzed using Load Resistant Factor Design using American code AISC 360-10 CODE. STAAD Pro V8i software has been used to analyze and design Super structure using STAAD Pro software. The members of the pipe rack are suitably verified for strength, vertical and horizontal deflection. The overall drift limit of the Pipe racks is also maintained within the desired limit.

The paper titles **"Comparative study and Cost Evaluation of combined Pipe Rack and Steel Pipe Rack"** authored by **Preeti Rathore and Prof. D.H.Raval.** Comparison of Combined pipe rack and steel pipe rack has been done in the paper. In all the three global directions, nodal displacements in a steel pipe racks are more due to lower stiffness of members. Also steel pipe rack is more flexible and reduces time of construction. But concrete gives better fire protection so combined rack is preferred. 45% Cost can be saved in combined pipe rack as compared to the steel pipe racks. In this study, cost of manufacturing of a combined pipe rack is about 23 lakh (INR) as compared to 42 lakhs (INR) cost of manufacturing of steel pipe racks, which is almost 1.8 times the combined pipe rack.

The paper titled **"Comparison Study of Effective Length Method (ELM) and Direct Analysis Method (DAM) for Piperack"** authored by **Sabade Madhuri, Prof. A.A.Hamane.** The paper aims to compare Effective Length Method and Direct Analysis Method for pipe rack. Both positive and negative aspects of each method of stability analysis is described. Process Industry Practices (PIP STC01015) and ANSI/AISC 360-05 for loads and loads combination is referred. Direct analysis method has no limitations as no front end calculations or post-analysis verification are required, also Effective length method provides relatively accurate results hence, direct analysis method is preferred by the author.

The paper titled **"Optimization of Pipe Rack by Study of Braced Bay"** authored by **M. G. Kawade and A. V. Navale.** In the paper three cases were considered for study. In this, first case is pipe rack with bracings are provided at 6th bay from either side, second is pipe rack with bracings at center and third is pipe rack same as case I with split at center. STAAD Pro software is used for the analysis and design. Loads considered in the structural calculations are Pipe Empty Load (DL), Pipe Operating Load (DL), Pipe Test Load (DL), Earthquake /Seismic Load (E), Pipe Anchor and Guide Load, Temperature load and Wind load. Vertical deflection of structural members is less where bracings are provided at the center. Bracings provided at the center is more economical than the bracings provided at the 6^{th} bay (CASE I) and bracings provided with split at center. According to the study steel required in case I where bracings are provided at the 6^{th} bay is 5% more as compared to case II i.e. where bracings are provided at the center. Also steel required in case III where bracings are provided with split at center is 4% more as compared to case II i.e. where bracings are provided at the center. Author suggested to provide bracings at the center for better most optimized design.

The paper titled **"Optimized design & analysis of steel pipe racks for oil & gas industries as per International Codes & Standards"** authored by **Nitesh J Singh, Mohammad Ishtiyaque.** The aim of the paper is to reduce the number of supports to reduce the total cost of erection. The value of stresses and deflection are kept within safe limit. The Structure has been designed in two parts as Strength design and Serviceability design. Footing is designed using STAAD Pro and Base Plate and Pedestal has been designed as per AISC codes considering support reactions. Framed connections between pipe and pipe rack are suggested in all supports. To reduce the forces, anchor bay is provided in each structure. It reduces overall size of the member and thus, the total weight of steel sections is reduced. Plan bracings are provided in K & L shape to resist lateral deflection and transfer the lateral load through vertical bracings.

The paper titled **"STABILITY ANALYSIS OF PIPE RACKS FOR INDUSTRIAL FACILITIES"** authored by **David A. Nelson**. For the representative pipe rack model, both pinned and fixed base conditions, the first order , effective length, and direct analysis methods were all found to be valid methods of stability analysis according to AISC 360-10. To provide the most accurate results since reduction in stiffness the direct analysis method is considered in analysis, the most significant benefits in applications of this method being that the effective length factor K can be set to 1 for all cases. The most well-known method for the stability analysis is probably the effective length method, for which the effective length factor K must be calculated. For determining K various methods have been developed but the most widely known is the still alignment charts because accuracy of effective length method is critically depends upon the accuracy of K. When the ratios $\Delta 2/\Delta 1$ and Pr/Py are below the list specified by AISC 360-10, all methods give comparable results.

The paper titled **"Seismic Response of Steel Braced Pipe Racks and Technological Platforms in Oil Refineries"** authored by **Rupam Saikia and Jayanta Pathak**. Author suggested the top node displacement, the shear force and the moments at joints are reduced as compared to the bare frame with MRC. Pipe rack with vertical irregularities should have additional bracings or horizontal struts to avoid larger displacement of the irregular pipe rack frames at the top nodes. Conventional X braced frame is the most efficient but considering the functionality and space provided by use of inverted V bracings is the alternative against conventional X bracings and in most of the cases it's performance was compared to X braced frame considered in study.

The paper titled **"Seismic Analysis and Component Design of Refinery Piping Systems"** authored by **Fabrizio Paolacci, Md. Shahin Reza, Oreste S. Bursi**. A pipe rack is the supporting and carrying structure employed for the pipelines and electrical instrument trayha. The seismic analysis of the building structure is different from the analysis of the piping systems, and for obtaining reliable design against earthquake a long experience has permitted to have enough provision. Therefore to design these types of structure a representative case study analyzed according to both European (EN13480:3) and American standards (ASME B31.3) devoted to piping systems. The structure is considered to be elastic because the common way to design a piping systems is based on the allowable stress approach, and while designing the system operating basis Earth quake condition (OBE) can be taken into account.

The paper titled **"Design of Structural Steel Pipe Racks"** authored by **Richard M. Drake and Robert J. Walter**. According to the author, Pipe Racks are not only Non-building structures that have similarities to structural steel buildings but also have additional loads and design considerations. The design requirements found in the building codes are not clear on how they are to be applied to pipe rack. It only dictate some of the requirements. Several industry references exist to help the designer apply the intent of the code and follow expected engineering practices. Additional and updated design guides are needed so that consistent design methods are used throughout the industry. Loads considered in the design are Dead load including Structural dead load (Ds), Operating dead load (Do), Empty dead load (De) and Test dead load (Dt), Live loads considering stairs and platforms, Thermal loads (T), Earthquake Loads (E), Wind Loads (W), Rain Loads (R), Snow loads (S) and Ice loads (Di). Load combinations are taken from ASCE 7.

The paper titled **"Dynamic response of pipe rack steel structures to explosion loads"** authored by **Anton Stade Aarønæs, Hanna Nilsson**. To perform dynamic explosion analysis of steel pipe rack, Static load is multiplied by a fixed Dynamic Amplification Factor (DAF). The project aims gain a better understanding of the dynamic behavior of pipe rack steel structures subjected to explosion loading and to provide accurate design in future projects. For design of base plates a reduction relative to the difference in DAF based on Overturning Moment and base shear can be accounted for. Author concluded that the dynamic amplification of structural details influenced by base shear can be designed based on the Biggs-curve while details mainly influenced by Overturning Moment cannot.

The paper titled **"Plant Layout Optimization with Pipe Rack and Frames"** authored by **Siyu Xua, Yufei Wanga, Xiao Feng**. In the paper, the layout of a chemical plant based on frames is optimized and its in-plant pipe rack is designed. The positions of departments are optimized considering the optimal material handling points, and then a proper in-plant pipe rack is designed. Departments are arranged on the basis of preliminary estimation of the closeness of the material exchange, which considers only the rough pipeline length and may lead to suboptimal solutions. The pipe rack of the original layout is a little longer compared with the optimized layout. The optimized pipe rack is proved to be better as it reduces around 9% of the pipe rack cost and 40 % of the pipeline related costs. The effectiveness of the placement manner of departments can also be well reflected. Original plant layout is manually determined according to the relationships between frames and high facilities. Departments with more connections are positioned as close as possible to reduce the total pipeline length, so as to reduce the length and cost of the pipe rack.

The paper titled **"Rational Hybrid Analytical Model for Steel Pipe Rack Quantification in Oil & Gas Industries"** authored by **Manoharan R. and Amit Srivastava**. The paper aims to develop an analytical model to overcome the shortfalls in current engineering practices that are being used to estimate the pipe rack steel quantities during the pre-bid engineering phase in Oil & Gas industries. It is concluded that in terms of the steel incidence ratio, the results obtained through the rational hybrid analytical model are much closer to the actual detailed engineering results, which is the basis for the quantification and pre-bidding calculations. It is also clear that the hybrid model comes out slightly on the conservative side, which is necessary for the pre-bid engineering phase. It also takes much less time than the rigorous software method. The research methodology consists of performing data analysis of past projects and devising a new system by developing suitable structure formulation techniques, loading system creation, structural stability analysis and LRFD design calculations, along with steel quantification procedures, which are completed in a single run. It has been discovered that the rational hybrid analytical model will be of much use to structural engineers in calculating steel quantities more accurately and in less time.

The paper titled **“Linear and nonlinear analysis for seismic design of piping system”** authored by **Ali Reza Keyvani Boroujeni and Mehdi Hashemi**. Two programs are studied; in the paper, (1) the evaluation of ASCE methods (2) offer of the improved method for supporting structures design. This research paper concludes that, the petrochemical plants are contained in various pipes and industrial structures. Therefore, the applicable design methods are required. The scaling method has the advantage and is also applicable for structural design. Result of this evaluation show that scaling method satisfies the piping system performance for the supporting structures. Therefore, this method can be used for pipe rack and Pipe Bridge design. According to this result, the pipes which are being design should be controlled for differential displacement. So the scaling method is reliable for piping system design while the pipe is finally controlled.

3. CONCLUSION

This study results the following conclusions:

1. In the comparison of Modular structure with the normal structure, modular structure possesses heavier steel design, hence it is more economical.
2. The members of the pipe rack should be suitably verified for strength, vertical and horizontal deflection. The overall drift limit of the Pipe racks should also be maintained within the desired limit.
3. Maximizing the distance between supports by keeping the value of stresses and deflection within safe limit reduces cost of the project.
4. In the comparison of combined pipe rack and steel pipe rack, steel pipe rack is more flexible and reduces time of construction. But concrete gives better fire protection so combined rack is preferred.
5. Provide bracings at the center for better most optimized design.
6. The rational hybrid analytical model will be of much use to structural engineers in calculating steel quantities more accurately and less in time.

REFERENCES

[1] Ashit K. Kikani and Vijay R. Panchal, “Comparative Study of Pipe Rack Structure with Modular Concept and Normal Stick-built Approach using ASCE 7-02” *Journal of Civil Engineering and Environmental Technology* p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 3, Issue 4; January-March, 2016, pp. 303-307.

[2] J. K. Sumanth and Dr. C. Sashidhar, “Design and Analysis of Pipe Rack System using STAAD PRO V8i Software,” *International Journal for Research in Applied Science & Engineering Technology* (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue IX, Sep 2018

[3] Preeti Rathore and Prof. D.H.Raval, “Comparative Study and Cost Evaluation of Combined Pipe Rack and Steel Pipe Rack,” *IJSRD - International Journal for Scientific Research & Development*| Vol. 4, Issue 03, 2016

[4] Sabade Madhuri, Prof. A.A.Hamane, “Comparison Study of Effective Length Method (ELM) and Direct Analysis Method (DAM) for Pipe rack,” 2017 IJSRSET | Volume 3 | Issue 2 | Print ISSN: 2395-1990

[5] M. G. Kawade, A. V. Navale, “Optimization of Pipe Rack by Study of Braced Bay,” *International Journal of Research in Engineering, Science and Management* Volume-2, Issue-2, February-2019

[6] Nitesh J Singh, Mohammad Ishtiyaque, “Optimized Design & Analysis of Steel Pipe Racks For Oil & Gas Industries As Per International Codes & Standards,” *IJRET: International Journal of Research in Engineering and Technology* eISSN: 2319-1163 | pISSN: 2321-7308

[7] David A. Nelson, “Stability Analysis Of Pipe Racks For Industrial Facilities”

[8] Rupam Saikia and Jayanta Pathak, “Seismic Response Of Steel Braced Pipe Racks And Technological Platforms In Oil Refineries” *15th Symposium on Earthquake Engineering Indian Institute of Technology, Roorkee December 11-13, 2014* Paper No. A127

[9] Fabrizio Paolacci, Md. Shahin Reza, Oreste S. Bursi, “Seismic Analysis And Component Design of Refinery Piping Systems”

[10] Richard M. Drake and Robert J. Walter, “Design of Structural Steel Pipe Racks”

[11] Anton Stade Aarønæs, Hanna Nilsson, “Dynamic response of pipe rack steel structures to explosion loads”

[12] Siyu Xua, Yufei Wanga, Xiao Feng, “Plant Layout Optimization with Pipe Rack and Frames,” CHEMICAL ENGINEERING TRANSACTIONS(CEt) VOL. 81, 2020

[13] Manoharan R. and Amit Srivastava, “Rational Hybrid Analytical Model for Steel Pipe Rack Quantification in Oil & Gas Industries” *Civil Engineering Journal* Vol. 6, No. 4, April, 2020

[14] Ali Reza Keyvani Boroujeni and Mehdi Hashemi, “Linear and nonlinear analysis for seismic design of piping system” *Journal of Civil Engineering and Construction Technology* Vol. 4(4), pp. 149-156, May, 2013 DOI 10.5897/JCECT12.090 ISSN 1996-0816 © 2013 Academic Journals

Effectiveness of Natural Coagulant and Chemical Coagulants in Coagulation Flocculation Process: A Review

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Abstract:
In coagulation and flocculation process, most commonly used coagulants include alum, lime, ferric sulfate, and polymers. Unfortunately, there are various drawbacks of using this type of chemical coagulants for treating water in a water treatment process. To minimize various pitfalls of using chemical coagulants and to resolve most of the problems created using chemical coagulants, the popularity of using natural coagulants have been increasing in the past few years. Present study is an effort undertaken for comprehensive review of literature related to previous researcher’s efforts to find the possibility of various natural coagulants as an alternative to commercial synthetic coagulants which can optimize the coagulation process. The article critically reviews the application of chemical coagulants and natural coagulants (herbs powder) in the area of water treatment. A number of natural coagulants are reported for their flocculation behavior for treating the water and making it suitable for drinking.

Index Terms: ***Coagulation, natural coagulants, synthetic coagulants.***

I. INTRODUCTION

As the population grows, there is always an exciting need to keep growing the corrective action according to present and future problems. In the rainy seasons, the turbidity level increases, and the need for water treatment chemicals increase as well, which leads to the high cost of treatment which the water treatment companies cannot sustain. The acknowledgment by the government, allow having on-going collaboration research between higher education, academic institutes, and professional sectors to come out with sustainable solutions [17]. Clearwater is a fundamental need of living creatures and human beings. Turbidity may increase in rainy season, erosion of soil and plant and animal life in the water also contributed in increasing turbidity. Turbidity and water quality have a significant impact on local communities. Therefore, it necessitates the importance of treating drinking water prior going to the consumer. To treat the turbidity is of great importance of natural and chemical alternatives as a coagulant for water treatment as suggested by [14]. The coagulants are the critical factor in determining the coagulation performance, as they can uplift or hamper the treatment efficiency, suggested by [15]. The termenology of coagulation-flocculation process has been used more largely in diverse method of water treatment according to [14]. The simple operating conditions are said to be one of the components for the treatment to be selected. Other than the type of coagulants, some components have been pointed out to help the regulation of coagulation, that is dosage of coagulant, pH of the sample, mixing speed of flocculation and its duration, temperature, and settling time of the sample, stated by [17].

According to researchers, the locally available natural coagulants are used to reduce the turbidity of water as Sapodilla seeds, Okra. Seeds, Watermelon seeds, Cicer arietinum, Azadirachta indica (neem leaf powder) etc. Different types of natural coagulants can be used in the water treatment process. Also, Chemical Coagulants are Aluminum Sulphate and Ferrous Sulphate are traditionally used for the treatment of water. The current study is to list out various chemical and natural coagulants which can be effectively used in a coagulation, flocculation process for removing turbiity.

II. NATURAL COAGULANTS

1.Dolichos Lablab

Dolichos Lablab is scientific name of seim beans. These are herbs and shrubs growing upright, sometimes with climbing stems. This climbing plant is usually made into silage with its high nutritional content, especially protein and carbohydrates, these seeds are also eaten as beans. Apart from this, its Conventional usages, the seeds have been added as a natural coagulant for treatment of water. The synthetic water goes on optimized condition 95% of turbidity is

removed. The plant extract gives the best result at pH values near neutral of 7.5 which is ideal. Dolichos lablab demonstrated the best performance with high turbidity water. The compensation of destabilized colloidal particles, which was associated with higher residual turbidity, occurred at doses above the optimal. It is commonly observed that particles are destabilized by less numbers of hydrolyzing metal salts and that optimum destabilization corresponds with the neutralization of particles' charge. The effective coagulation activity is described by [7]. An ideal dose of 200 mg of this coagulant occured in 68% coagulation activity for clarification if water along with inactivation of bacteria in 60 min [16].

2. Okra Seeds

Okra Seeds are commonly known as lady finger is one of the important vegetable crops grown in the tropical and subtropical region of the country. Studies represent that the volume of Gumbo mucilage (a thick syrupy substance) decides the pH which changes the turbidity of the water. In tannery to clean effluent, okra seed acts as a very effective flocculent and is capable of removing more than 90-94% of suspended solids and 30-44% of total dissolved solids. He also worked on the utilization of natural coagulants for water treatment and discovered that the sludge produced from the use of okra seed able to remove turbidity from water upto 20-30% better than that obtained from the use of alum [5].

3. Water Melon Seeds

Watermelon (Citrulluslanatus) is a member of the cucurbit family. The crop is grown monetarily in areas with long frost-free hot season and the crop may be settled in the field by planting seeds or using containerized transplants. Watermelons have four distinct parts namely the rind/peel, the seed, the portly white, and the fleshy red/pink/yellow parts. The seeds can find to be brown, white green, or yellow and a few varieties are seedless. Watermelon seeds are an origin of protein, B vitamins, and many types of minerals and fat among others. When watermelon seed cake was used in combination with alum higher color and turbidity removal was observed, going as high as 100% clarification of color. However, Recommended ratio for the combined coagulant dose was 80% watermelon seed powder and 20% alum as the best water treatment suggested by [13].

4. Azadirachta Indica

Azadirachta Indica is the scientific name of neem leaves. Neem is kinfolk of the Meliaceae parentage

and its role as a health-promoting effect is attributed because it is a rich source of antioxidants. It has been gradually used in Chinese, Ayurvedic, and Unani medicines worldwide especially in the Indian Subcontinent in the treatment and prevention of various diseases. Ultimately finding confirmed that neem and its components play role in the scavenging of free radical generation and prevention of disease pathogenesis [1]. Neem leaves are a very effective adsorbent for the removal of Cr ions from the given water sample. It gave maximum adsorption at a contact time of 75 minutes and an adsorbent dosage of 0.7 g/L. The maximum percentage removal of Cr (VI)was found to be 86% [4].

5. Cicer Arietinum

Cicer Arietinum is also commonly known as (Chick Pea) /(chana) seeds were investigated as an alternative natural material for treating surface to minimize the problems that arise with chemical coagulants like Alum. A threat to human health named Alzheimer's disease is associated with the excess aluminum in treated water. Therefore, alternative natural coagulant material has been decided as a solution by various researchers. The study of lab results illustrates that natural coagulant helps reducing turbidity of different turbid water 80, 150, 250 NTU sample and gives a better result as 88.6% ,90.5% ,93.85% respectively [12]. In addition to this [12] reported the various advantages of these natural coagulant as effectiveness, economical, eco-friendly, and also biodegradable in the process of water purification. Turbidity increases in the rainy season because of the erosion of soil and runoff. In such cases, for the higher turbidity levels, the natural coagulant (Cicer arietinum) is much effective for the removal of turbidity in the water purification process [6]. According to [6] Cicer arietinum dosages, stirring time, and rapid mixing time are the three parameters which plays important role in purification process while using Cicer arietinum as a coagulant. Experimental data shows 52.74% of turbidity was successfully removed with addition of coagulant dosage of 12 mg/L where rapid mixing of 120 rpm is required for 4 mins [6].

6. Cactus Powder

A Cactus is a member of the plant parentage Cactaceae. [2] describe the procedure of the preparation of cactus powder, by using the inner pads of cactus Opuntia, where cactus pads were sliced, dried (8 h at 80˚C), ground into a fine powder, and then sieved to size 53 – 106 µm so as to get the powder form of it. [2] conducted experimentation considering cactus powder as a coagulant. He tested cladodes of

Cactus powder as a coagulant for turbid water treatment and the obtained results showed a higher level of turbidity removal. Cactus-based materials are also very useful for water treatment. Cactus plants are renewable, generous, eco-friendly, adaptable, and biodegradable. The cactus can be used as a coagulant/flocculant, as sorbent, and as packed material for biofilter. The limit of using cactus in wastewater treatment is related to the variability of efficiencies of cactus preparations, which depends on water parameters. Also, the technology performance should be evaluated at a large scale in real conditions for various water treatment plants described by [8].

7. Moringa Oleifera

Moringa Oleifera is a scientific name for drumsticks. Moringa oleifera tree is a deciduous tree; it can reach up to 10–12 m (32–40 ft) height with 45 cm (1.5 ft.) trunk diameter. [11] confirmed that after oil extraction of Moringa seed, the Moringa seed flour can be used as a fertilizer or as a flocculant to remove water contaminants. To produce potable water for domestic consumption Moringa seed flour can be used in water treatment with flocculation process technology. The other benefit of using these seeds include, it can absorb and neutralize colloidal charges in turbid water to remove sludge. Moringa seed used for nontoxic and sustainable coagulants compared to other materials where drinking water was polluted. Literature shows use of Moringa seed as coagulant/flocculants causes better results for water treatment rather than for wastewater treatment. [21] reported the correlation between the ionic strength in the solvent and extraction yield shows significant results. In the experimentation [11] concluded, Moringa Oleifera can remove color and turbidity removal was more than 90% which is significant.

III .CHEMICAL COAGULANTS

1. Aluminum Sulphate

Aluminum sulphate is commonly known as Alum. It has been the most popular as a chemical coagulant for the treatment of water and widely used in treatment plants. The chemical formula of Aluminum Sulphate is $Al_2(SO_4)_3$. The municipal water suppliers use to make ready water for distribution clear and particulate-free as possible. To execute this, Raw water generally holds tiny suspended particles that are very difficult for a filter to catch. Alum causes them to tramp together so that they can settle out of the water or be easily catcher by a filter. The alum upgrades the coagulation of fine particles which helps resolve problems of color as well as turbidity. If the process is given adequate time to work and is applied properly, it not only corrects problems in the water but results in seperating most of the aluminum used in the process [3].

2. Ferrous Sulphate

Ferrous sulphate is also termed copperas, iron sulphate, or sugar of iron. This salt is cheapest of all salts that can be used for coagulation. From the previous time, it has been widely used in drinking water treatment, in combination with chlorine as chlorinated copperas. The probability of the formationof trihalomethanes (THM), by the action of the surplus chlorine required to complete the chlorination reaction, has generating the reason for using this coagulant to be largely or entirely ceased in the publicwater supply sphere suggested by [15].

IV. PREPERATION OF NATURALCOAGULANT

Plant-based natural coagulants extracted from various plant components are used as a natural coagulant. Collaborative research and development efforts have been conducted in finding various plant species and its constituents that can be effectively used as natural coagulants, boosting the performance of existing plant-based natural coagulants. Generally, natural coagulants are not easily available in a usable form and required to be prepared. The procedure of preparation of some natural coagulants are same and with slight changes some of the other coagulants can be prepared. Coagulant preparation procedure is as listed below

Okra Seeds Coagulant

The okra seeds were drawn from a local market. The seeds were initially cleaned to remove all impurities in it, they are sun-dried for 24 hrs. at normal temperature,then crushed the dried seeds using pestle and mortar toobtaining powdered form and screen to 500 µ particlessize to remove the large particles size of the seeds.[5].

Watermelon Seeds Coagulant

Watermelon seed (coagulant) preparation Fresh seeds of watermelon (Citrullus lanatus) of the Cucurbitaceae family were obtained from the local market. The fruits were sliced open using a clean stainless steel lab knife. The seeds were cleaned exclusively with water, sun- dried for a week, sorted to seperate bad ones, shelled, and ground with a high-speed laboratory electric blender, packed in an air-tight container. 150g of the crushed seeds were then packed in a thimble and put down in a soxhlet extraction apparatus. 500ml of the

n-Hexane was used to extract oil from the squashed seed in the column. The apparatus was left running for about 6hours and stopped when the evacuation was complete. The cake was then washed with distilled water to remove n-Hexane, dried in an oven till constant weight, and then sieved. The finer particles were then used as the coagulant [13].

Azadirachta Indica Coagulant

Azadirachta Indica plant extracts and fresh leaves were washed with sterilized distilled water and 70% alcohol. The leaves were then dried, blended, and mixed with either sterile distilled water or ethanol, or methanol. The extracts were then placed in a shaking incubator at 37°C and 120 rpm for 72 hours. The extracts were then filtered, centrifuged, and were collected. The mixtures were then shaken vigorously to allow for proper extraction and filtering. Ethanol was produced from leaves were washed with sterile distilled water and 70% alcohol. It is air-dried, and then crushed by mortar and pestle. Raw juice was then filtered and collected. The prepared coagulants were stored in airtight plastic containers [4].

V. JAR TEST METHOD

The Jar test is the most common method used in coagulation studies. However, there is no internationally accepted standard procedure or equipment for this test. Jar test method can be accomplished with any one of the five shapes of mixers as radial, axial, wheel, magnetic, and 3-blades. These assembly can properly disperse the coagulant into the water to be treated. The magnetic stirrer produces different conditions within the fluid to the other mixers but is a common mixing apparatus in the laboratory. By performing jar test, the alternative treatment doses, and strategies without altering the performance of the full-scale treatment plant can be analysed. The results obtained from jar test can be easily compared for the several different chemical treatments and combinations. Results can also be compared and studied for the time of formation of flocs, floc size, settleability, and filtration characteristics. The jar test method is a low-budget method of the Coagulation flocculation process. Coagulation is performed in two stages: first, the

 ISBN: 978-93-90214-19-8

coagulant is rapidly mixed and then flocculation is enhanced by slow mixing. Hence, the optimized dosages were further optimized for varied mixing speed and time for each event of coagulation as described by [13].

VI. CONCLUSION

This comparative study is an effort to know the efficiency of different natural and chemical coagulants in treatment of surface water. Researchers have reported number of natural coagulants and has demonstrated significant advantages since it provides a low cost and environmentally friendly technology for removing dyes. This study aimed at evaluating theperformance of different chemical and natural coagulants in the removing turbidity. Study shows that both the chemical and natural coagulant plays a vital role in the water treatment process. When compared to chemical coagulants, natural coagulants takes the advantages of lower maintenance costs, Produce a lower amount of sludge, less toxic, cheaper to manage,easy availability, required less time to settle out suspended solids and it is very effective in removing fine particles. Focusing on the benefits of using natural coagulants in treatment more research, innovation and technical development is essentially required inparticular area.

REFERENCS

1. Amir Hariz Amran1, Nur Syamimi Zaidi, Khalida Muda Loan Faculty of Civil Engineering, University Technology Malaysia, 81310 Skudai, Johor, Malaysia(2017).

2. Chacin E, Forster C.F., Proc. Biochem (2017), Journal of Materials and Environmental Sciences, University of Mohammed 1er Oujda Morocco Cactus an eco-friendly material for wastewater treatment.

3.Chen Y, Basic aluminum sulfate and graphene hydrogel composites: preparation and application for removal of fluoride, Journal of Material Chemistry.

4. Islamuddin Assistant Professor, Department of Civil Engineering Babasaheb Bhimrao Ambedkar Central University Lucknow, Indianise in adsorption capacity, International Research Journal of Engineering and Technology (IRJET) (Aug-2016)

5. Idris Muhammad Misau, Abdulwadud Abdulkarim Yusuf, Department of Chemical Engineering, ATBU, Bauchi, Nigeria, corresponding author: immuhd@atbu.edu.ng

6. Jhoan Jaramillo, Jesús Epalzab a University of Valladolid (UVA), Environmental Engineering, Environmental Engineering, Bucaramanga, Colombia, Study of the Phytochemical Kabuli Chickpea (Cicer Arietinum L) as an Anionic Coagulant for the Treatment of Water, A publication of The Italian Association of Chemical Engineering, Online at www.set journal.

7. Komal R. Asopa, S. R. Korake (2016) Use of Sapodilla Seed and Dolichos Lablab in Treatment of Grey Water.

8. Khamis Mushait, King Khalid University, Saudi Arabia. Higher Institute of biotechnology, Atomic Energy Commission, Khartoum, Sudan. Journal of Materials and Environmental Science, University of Mohamed Oujda Morocco Cactus an eco-friendly material for wastewater treatment: A review

9. Kavya Gurumath, Dr. S. Suresh, Department of Environmental Engineering, BIET, Davangere, Karnataka, India 2Professor, Department of Environmental Engineering, BIET, Davangere, Karnataka, India International Research Journal of Engineering and Technology (July 2019)www.irjet.net p-ISSN: 2395-0072 © 2019, IRJET

10. Kumar, V., Othman, N. & as, S. 2017. Applications of natural coagulants to treat wastewater - A review. MATEC Web of Conferences 103(ISCEE 2017).

11.Lea, M., Bioremediation of Turbid Surface Water Using Seed Extract from Moringa oleifera Lam. Drumstick) Tree. Current Protocols in Microbiology. (2010)

12. Meor Muhammad Hafiz Shah Buddin, Muhammad Ibnu Hakim Shuhaini, Farah Adibah Abd Halim

Malaysian Journal of Chemical Engineering & Technology (27 sept 2012)

13. M. Muhammad, S. Abdulsalam, A. Abdulkarim & A.A. Bello, Global Journal of Researches in Engineering: C Chemical Engineering Volume 15 Issue (The year 2015) Type: Double Blind Peer Reviewed International Research Journal Publisher

14. Maryam & Buyukgungor (2017), A Review of Wastewater Treatment Using Natural Materials and Its Potential as Aid Composite Coagulant.

15. Mbaeze MC, Agbazue VE, Comparative assessment of the performance of Aluminum sulphate and ferrous sulphate as coagulants in water treatment, journal of modern chemistry and application (2017)

16. Syeeda Azeem, Punam deepthi, Efficiency studies with Dolichos and solar disinfection for treating turbid water (2010).

17. Rutz Rui. (2012), Coagulation-flocculation in leachate treatment by using micro sand., InternationalJournal of Engineering.

18. Siti nor Aishah Mohd-Salleh, Nur Shaylinda Mohd-Zin & Norzila Othman, (2016) A Review of Wastewater Treatment using Natural Material and Its Potential as Aid and Composite Coagulant

19. Sneha Singh Ruchira Srivastava, Amity University Greater Noida Uttar Pradesh India International Journal for Research in Applied Science& Engineering Technology (IJRASET) Issue VI, (May 2017)

20. S.N. Ugwu1, A.F. Umuokoro, Department of Mechanical and Industrial Engineering, University of South Africa, Department of Agricultural and Bioresources Engineering, University of Nigeria, Comparative study of the use of natural and chemical coagulants for the treatment of water Received: 29 May 2017, accepted: 07 August 2017, First Published:24 (August 2017)

21. Villasenor-Basulto, D., L., Astudillo-Sanchez, E., R. Wastewater treatment using Moringa oleifera Lam seeds: A review. Journal of Water Process Engineering23 (2018)

22. Xernando, Karamany, The Impact of Selected Water and Wastewater Treatment Process Variables on Sludge Dewaterability, (2010).

23. Zane Satterfield, P. E., NESC Engineering Scientist Photos by Julie Black, courtesy of Morgantown Utility Board, (2016)

A Review Paper on Requisite of Green Building

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Abstract - Green building technology is one of the most trending topics all over the world which is been put forward to reduce the significant impact of the construction industry on the environment, society and economy. The globe is in an urgent need of sustainable and a smart development as the problem of pollution and global warming is rapidly increasing all over the world. Green building refers to a structure and using a process that is environmentally responsible and resource efficient through out a building's lifecycle. Since buildings consume nearly 50% of world's total energy, green buildings, on the other hand, consume minimum amount of energy with the use of energy efficient materials. Hence, location of green buildings in the close proximity would create a green zone and providing much healthier environment with minimum heat island effect. In India there are two primary rating systems for green buildings GRIHA (green rating for integrated habitat assessment), LEED (Leadership In Energy and Environmental Design).

The LEED Green Building rating system developed and managed by the USGBC, is the most widely used rating system nationally and internationally. Buildings are given ratings of platinum, gold and silver or "certified", based on green building attributes. The Indian green building council IGBC founded by collaboration between the confederation of Indian industry (CII) and the private manufacture Godrej, has taken steps to promote the green building concept in India. LEED-India rates on buildings on environmental performance and energy efficiency during design , construction and operation stages . Green Building when compared to a conventional building seems same extremely and in building use but differs in the operational savings and concerns for human comfort and indoor and environment. Green buildings enjoy the benefits of saving 40-50% energy by reducing CO2 emissions into the atmosphere it also saves about 20-30% of water by using rain harvesting or grey water re-use techniques. It also reduces VMT(Vehicle Miles Travelled) by choosing the location near by public transport and conveniences which helps in reduction of gasoline consumption. But on the other hand, green buildings face many barriers like the high initial investments required for construction, spilt incentives.

Keywords: GRIHA (Green ratings for integrated habitat assessment) LEED (Leadership in Energy & environmental Design) Classification, Conclusion, Reference.

INTRODUCTION

WHEN SMART MEETS GREEN WHAT DO YOU GET ??
THE
S.M.A.R.T.
GREEN
TECHNOLOGY BUILDING
S.M.A.R.T.
•S=Sustainable
•M=Meaningful
•A=Applied
•R=Research
•T=Training
+
G R E E N
=
S.M.A.R.T. GREEN TECHNOLOGY

- Green building (also known as green construction or sustainable building) expands and complements the building design concerns of economy , utility, durability, and comfort.
- This research paper will help developing green buildings and eco-friendly homes in India as it includes easy and simple ways to be implemented for achieving green homes and also the importance and long term profits involving green homes.
- A Green Building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier space for occupants as compared to conventional building
- Market estimates suggest that India will be adding 11.5 million homes every year thus, making it the world's third largest construction market by 2020. With rapid urbanization and strong economic growth, the construction industry is becoming one of

the fastest growing sectors in India providing employment to nearly 18 million people.

- This will be beneficial for the people who are really conscious about the environmental impact of the buildings and believe in energy conservation.
- Economy is the major factor in any type of construction work, especially for residential houses and more specifically when they are situated in the megacity in a developing country like India.
- There is a need of concentrating on a Green Home, which is one of the most important and one of the discussed topics throughout the globe, in the age of global warming and climate change worldwide.
- In this situation, some middle way is necessary to be found out, to encourage the green construction

RESEARCH BACKGROUND

Childers (2008) quoted Jeff Komblau : Conclude that To protect the environment by using Green Techniques New developments are made every day in the field of engineering that are meant to save energy and protect the environment. Using the materials are available near to the site of construction is economical, environmentally sound and energy efficient way to decrease pollution. Also, rather than building a new building, renovating an existing building is not only benefits economically but also a great step to 'go green'. It helps the environment; in that it provides a habitat for wildlife that was likely there before the building was built. The water runoff from the top of a green roof also drains cleaner than it was before it hit the roof.

Mr. Jiauzuo and Mr. Zhen YU Zheo (2017) : Mr. Jiauzuo and Mr. Zhen YU Zheo carried out research work with on the green building and also stated as current status 07, July, 2017 To understand plan and design Gren Building that has been achieved by studying different green technology for building. Efficiently using energy, water and other resources. The region can affect what type of green technology would work because of varying climates. Solar panels, for example, are only substantially effective in areas with lots of direct sunlight. the One simple area that could save energy in any size building is the lighting. Natural light is one approach that could be taken during the design process, but if that is illogical, the use of ecofriendly and energy saving light bulbs would help.

Torgal, F. and Jalali, S. (2011) : Studied That "Eco-efficient construction and green building material," Verlag, London Springer Limited. Green buildings' is a popular term used for environment friendly buildings. Green buildings have minimal impact on the local and global environment. green buildings are minimum disruption of natural surroundings, reduced energy and water consumption, use of environment friendly materials, and adequate comfort conditions for the occupants. Green building construction has seen rapid growth in popularity and importance. Many businesses are taking advantage of this evolving sector and encouraging more change at the same time. The Author Conclude that final stage, major cases, makes the technology affordable and user friendly. Consumers can harness these technological developments and take the road that will reach to healthy earth and save money in their wallet.

Usman Aminu Umar, M. F. Khamidi, Hassan Tukur (2008) : Sustainable building Material used for green building Construction. By Reducing waste, pollution and Environment degradation. Use of eco- friendly material in green building like Fly ash blocks, High volume Fly ash concrete, Solar Reflection Glass. sustainable building material needs to be used properly and contextually in every community development. The application of sustainable building materials not just minimizes transport costs, carbon emissions, and in most cases materials costs, it also offers employment and skills development opportunities for community members.

METHADOLOGY FOR MAKING GREEN BUILDING

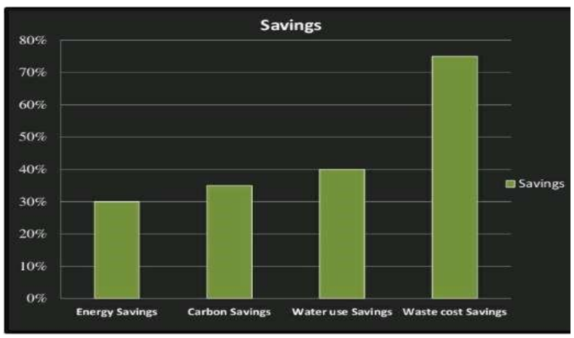
This study is aimed at research, study and development of the green building construction techniques in order to save our planet from pollution and global temperature rise. Also, it aims at spreading awareness among the people all over the world, about the advantages and also the long term cost savings from green buildings. Further, the structural methodology is structured as below:

1. Introduction
2. Location
3. Energy Efficient Equipment
4. Proper Insulation
5. Data collection from the proposed areas of study which includes large, medium and small scale construction projects.

6. Reduce Reuse Recycle of Material.
7. Use Sustainable Building Material.
8. Install Solar Panels & Eco Friendly lighting.
9. Water Conserving Fixtures.
10. Collection of information with the help of web surveys.
11. Finding out new ways and techniques for development of green construction.

Savings of Green Building

Average savings of Green Buildings.



MATERIALS FOR GREEN BUILDING

1. Compressed Earth Block

• It's a compressed mix of dirt, non-expansive clay and aggregate.
• Slurry used for bonding of CEB is also of same mixture of dirt and clay.
• Simple in manufacturing so, It can be prepared near the construction site.
• Economic since it uses dirt and clay which is not expensive at all.
• Fire resistant, Sound Resistant, Non-toxic in nature.

ii) Fly ash Blocks

• Mix of Fly ash and Lime
• Fly ash is a by product of Thermal power plants.
• Thus Fly ash, a waste material is utilized for construction.
• Fly ash is very cheap (only cost of transportation) hence the blocks are also economical
• Possess high strength, good finishing and uniformity in size which reduced quantity of plastering.
• Low water absorption

iii) High Volume Fly Ash Concrete

• About 50 % of the cement is replaced by Fly ash in HVF Concrete, Thus reducing use of cement and utilizing waste material
• More economical as compared to ordinary concrete
• Fly ash replacement doesn't alter its strength if correct proportion is maintained
• Improved workability, reduced segregation and bleeding, increased pump ability
• In long term, less W/C ratio, increased strength, less shrinkage, low heat of hydration Improved workability, reduced segregation.

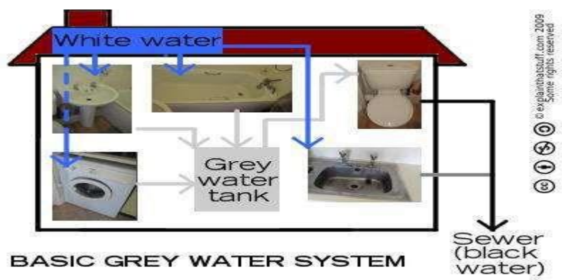
a) Water Efficiency :-

Water Efficiency can be achieved by,
• Treatment of waste water and Recycling of Grey water.
• Water conservation and ground water recharge by Rainwater harvesting .

ISBN: 978-93-90214-19-8

• Controlled water use and wastage reduction .
• Reducing storm water runoff by efficient landscaping

b)Recycling of Grey Water:
Grey water is waste water form laundry, dishwashing and bathing which can be recycled on site Without purifying it can be used for landscaping and some other agricultural purposes With purification it can be used for bathing, toilet flushing, car washing and other purposes except drinking and cooking. It has many benefits including less impact on treatment plant, lower fresh water extraction, top soil nitrification.

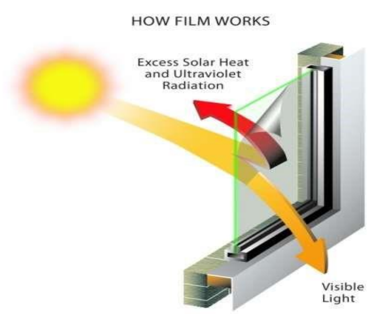


c)Rain Water Harvesting :
• Collection and utilization of storm water.
• Storm water can either be stored on site and used later or it can be recharged into the underground aquifer.
• RWH system are beneficial individually as well as for society in case of ground water recharge.
• Reduced runoff, less extraction of fresh water, less load on treatment plants, improvement in regional ground water table.

IV Low VOC Paint:-
• These paints are comparatively more expensive then ordinary paints but they are still preferable because of there reasonable advantages.
• Low VOC paints reduces Ozone depletion and improves indoor air quality

Paint Product	VOC in gm/liter	Rate pre Liter in Rs.	Rate per liter of similar ordinary paint in Rs.
Tractor emulsion smooth wall finish	24.14	124	118
Royale Luxury emulsion	55.62	380	315
Apex Utima Weather proof exterior emulsion	33.67	310	285
Apex weather proof exterior	32.31	235	210
Premium emulsion	41.30	235	205

V. Sloar Reflective Glass :-
• These glass are feasible because they controls the infrared rays of sun keeps indoor environment cooler then outside.
• They are more expensive then ordinary glass but still economical if the expenses of electricity for Air conditioning are also considered.



VI. Building Intergated Photovolatic :-

• Photovoltaic (PV) Panel converts Solar power in to useful Electricity.
• These PV modules can be installed on walls and rooftop of building.
• Clean (eco-friendly) source of electricity.

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• Reduces consumption of conventional thermal electricity.
• Proves to be economical in long term

CONCLUSION

This paper study reported all the technical and also the economic aspects related to green buildings worldwide. Also, through this live case study of a small residential bungalow in a small town of India it is expected to attract at least the researchers all over the world especially in India and also to all the readers towards planning of their new homes or retrofitting their old ones by simple modifications and converting it into a green or a sustainable building for future long term savings (economic aspects) and also for saving our environment (environmental aspects). The conclusion for the studies can be classified into three different categories i.e. definitions and scope of green building, benefits and costs of green building and ways to achieve green building. It has been observed that in most of the literature reviews, the focuses are on environmental aspects of sustainability such as energy consumption, water efficiency and greenhouse gas emissions and also with their technical solution.

Green Building that has been achieved by studying different green technologies for buildings, by planning and designing building layout, development of plan, elevation, sections etc. Various Green technologies and materials proposed with their feasibility study and cost comparison. So, on the bases of the above figures, it can be concluded that:

"If the intention is to construct a new Home to live in, it is advisable to go for a GREEN HOME rather than the ordinary conventional home. Because, the percentage increase of 12.94% in the total cost is not a negligible amount when the intention is just to renovate or retrofit an Old Home".

Green building is a financially, health, and most importantly environmentally responsible idea that more people need to adopt .The India green building council developed LEED in order to help Customers, designers, and builders to work together to create buildings with minimal impact on the environment possible. Build the green building to undertaken think for. "HUMAN COMFORTABLE WITH ECO-FRIENDLY"

REFERENCE

1)Case study by Saint- Gobain New North American , the LEED Platinum certified office (Core & Shell and commercial interior design office) spread over 277,000sq.ft, it has the capacity to accommodate more than 800 employees.

2)National Programme on Technology Enhanced Learning (NPTEL) lecture on Green building by Pro. Avlokita Agrawal IIT Banglore.

3) Childers (2008) quoted Jeff Komblau , director of sales and marketing for Eagle Construction of VA, Chadwick (2009) in his study on Green Building Construction.

4) Usman Aminu Umar, M. F. Khamidi, Hassan Tukur Sustainble building material used for green building (2008).

5) Sastry (2006) in his analysed the effect of a few building parameters on the energy consumption of the building A case study about the proposed Hitkarni College of Engineering and Technology, Jabalpur, can be mentioned here (2006).

6) Mr. Apoorva V. Kotkar, Prof. Hemant Salunkhe research work on the green building and also state the current status and also future agenda (07, July 2017).

7) Life cycle energy analysis of buildings; T.Ramesh, Ravi Prakash, KK Shukla.

8) Priyanka B. Kochhar, Senior Programme Associate at The Energy Research Institute (TERI) Economic benefits of green building(2010).

Study on properties of Self Compacting Concrete with the use of metakaolin

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Abstract - Self-Compacting Concrete (SCC) has the ability to flow and self-compact under it's own weight.It's main benefit that can reduce the construction time and labour cost. Self-Compacting concrete (SCC) has the ability to spread smoothly in congested reinforced elements due to its flowability and use of small size aggregates. SCC use in residential or large infrastructure for densely reinforced elements such as walls, precast members etc. Various agricultural and industrial waste are use as supplementary cementitious material in Self compacting concrete which enhances the properties of prepared self-compacting concrete. Metakaolin is also used as supplementary cementitious material. Metakaolin is a pozzolanic material and enhances the fresh as well as hardened properties of self-compacting concrete if it uses as partial replacement of cement.

Keywords: Metakaolin, Concrete mix, Compressive strength, Split Tensile strength, Flexural strength.

I. INTRODUCTION

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. Concrete that requires little vibration or compaction has been used in Europe since the early 1970s but self-compacting concrete was not developed until the late 1980's in Japan. In Europe it was probably first used in civil works for transportation networks in Sweden in the mid1990's. The EC funded a multi-national, industry lead project "SCC" 1997-2000 and since then SCC has found increasing use in all European countries. Self-compacting concrete offers a rapid rate of concrete placement, with faster construction times and ease of flow around congested reinforcement. The fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure. SCC is often produced with low water-cement ratio providing the potential for high early strength, earlier demoulding and faster use of elements and structures.

II. Literature review

Hassan et al. (2012) investigated the mechanical and durability performance of SCC by partial replacement of cement by metakaolin (MK). With the addition of MK, the viscosity of SCC mixtures increases which is based on the results of T50 and V-funnel tests, which showed an increase in flow time. When MK content increased from 0% to 25%, the values of H2/H1 (L-box index) increased from 0.63 to 0.89, indicating better passing ability. The compressive strength increased by 14 % by replacing 8% of cement by MK. The addition of MK to SCC mixtures improves resistance to freezing and thawing. MK significantly reduces the chloride permeability of SCC. When 20% MK was used (as a partial replacement of cement) the chloride permeability of the control mixture was reduced by 89%.

Brindha V. et al. (2015) investigate the mechanical properties of SCC containing metakaolin as replacement of cement. The addition of Metakaolin and Fly ash in SCC mixes increases filling ability, passing ability, flowing ability and segregation resistance.The compressive strength, flexural strength and split tensile strength of SCC increases for 7 days to 28 days of curing, of SCC by Metakaolin & Fly ash.

Jian Tong Ding (2002) investigated the MK or SK on the workability, strength, shrinkage and resistance to chloride penetration of concrete were investigated and compared in this study. For the given mixture proportions, MK offers better workability than does SF. As the replay\cement level was increased, the strength of the MK – modified concrete increased at all ages. The increase in the strength was similar to that of the SF – modified concrete. The incorporation of the both MK and SF in concrete can reduce the free drying the free drying shrinkage and restrained shrinkage cracking width. The initial cracking appeared earlier in the SFand MK- in concrete can reduce the chloride diffusion rate significantly, with the SF concrete performing somewhat better.

Nova John (2013) investigated the cement replacement levels were 5%,10%,15%,20% by weight for metakaolin. The strength of all metakaolin admixed concrete mixes over shoot the strength development of concrete. Mix with 15% metakaolin is superior to all other mixes. The increase in metakaolin content improves the compressive strength, split tensile strength and flexural strength upto 15% replacement. The result encourages the use of metakaolin, as pozzolanic material for partial cement replacement in producing high strength concrete. The inclusion of metakaolin results in faster early age strength development of concrete. The utilization of supplementary cementitious material like metakaolin concrete can compensate for environmental, technical and economic issues caused by cement production. Meta kaolin –The Best Material for Replacement of Cement in Concrete.

Dhinakaran (2012) studied the strength increases by MK concrete is effective only at the early age of concrete and in the long term the strength increase is only marginal. The increase in compressive strength for MK concrete was greater especially at higher water cement ratios (i.e., 0.4 and 0.5) and hence more suitable for higher w/cm ratios. From the studies an optimum percentage of MK was found to be 10% for all w/cm ratios except for 0.32 and for 0.32 it was 15%. MK concrete higher increase in strength at early ages beyond 28 days it was found to be less than 10%. The maximum compressive strength of 59.25 N/mm2 was observed at 0.4 w/cm with 10% MK. Addition of MK reduced the pH values, but the reduction is insignificant, since the pH values are still above 11.5, which will be helpful for maintaining the steel in a passive state itself. The depth of penetration of chloride ions for MK concrete is much lesser than control concrete. The minimum rate of reduction of chloride penetration depth for MK admixed concrete were arrived as 78%, 38%, 25% and 25% for w/cm ratios 0.32, 0.35, 0.40 and 0.50 respectively. The maximum rate of reduction was observed as 95% for 0.32 and 0.3 ratios.

Shelorkar ajay (2013) observed that the compressive strength of Metakaolin based HGC increases with the increase in percentage of Metakaolin. The variations of compressive strength of HGC with different Metakaolin content of 4 %, 6 % and 8 %. As the Metakaolin increases from 4% to 8% the compressive strength increases about 9.23 MPa for 4 % Metakaolin, 12.98 MPa for 6 % Metakaolin and 20.87 MPa for 8 % Metakaolin. The increase in compressive strength due to the addition of Metakaolin is due to pozzolanic activity. The compressive strength of HGC increases by 10.13 %, 14.24 % and 22.90% due to addition of Metakaolin content of 4 %, 6 % and 8 % respectively in comparison with control concrete specimens of HGC. The variation of RCPT values in HGC for different proportions of Metakaolin blended concrete. It has been observed that as the percentage of Metakaolin increase the permeability of concrete decreases. Also, it was observed that values of rapid chloride permeability of HGC decrease up to 1450 coulombs, 1548.67 coulombs and 1684.70 coulombs for 4% , 6% and 8% of metakaolin respectively in comparison to control concrete specimens. The percentage reduction in permeability values in coulombs was 48.57 %, 51.88 % and 56.43% for Metakaolin content of 4%, 6% and 8% respectively.

Patil (2012) studied the compressive strength of concrete increases with increase in HRM content up to 7.5%. Thereafter there is slight decline in strength for 10%, 12% and 15% due excess amount of HRM which reduces the w/b ratio and delay pozzolanic activity. The higher strength in case of 7.5% addition is due to sufficient amount of HRM available to react with calcium hydroxide which accelerates hydration of cement and forms C-S-H gel. The 7.5% addition of high reactivity metakaolin in cement is the optimum percentage enhancing the

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compressive strength at 28 days by 7.73% when compared with the control mix specimen. The 7.5% addition of high reactivity metakaolin in cement is enhanced the resistance to chloride attack. The compressive strength of concrete incorporated with 7.5% HRM is reduced only by 3.85% as compared with the reduction of strength of control mix specimen is by 4.88%. The 7.5% addition of high reactivity metakaolin in cement is also enhanced the resistance to sulfate attack. The compressive strength of concrete incorporated with 7.5% HRM is reduced only by 6.01% as compared with the reduction of strength of control mix specimen by 9.29%. The present study deals with the compressive strength, split tensile strength and flexural strength for cement replacement by metakaolin based concrete.

III. Material Used

1. Cement: OPC of 53 Grade confirming to IS:12269-1987 was used in the investigation.
2. Coarse Aggregate: Crushed stone metal with a maximum size of 20 mm from a local source conforming IS383-1970 was used.
3. Fine Aggregate: Locally available river sand passing through 4.75mm IS sieve conforming to grading zoneII of IS383-1970 was used.
4. Chemical Admixture i.e., Super Plasticizers and Viscosity Modifying Agents
5. Mineral Admixtures i.e., fly ash, silica fume, GGBFS etc.

IV. CONCLUSION

From the present investigation on the effect of partial replacement of cement with Metakaolin in concrete, the following conclusions were drawn;

- The strength of self-compacting concrete enhances with the use of metakaolin as a partial replacement of cement.
- The optimum percentage of metakaolin as a replacement of cement is observed as 15% in all types of mixes.
- The increase in Metakaolin content improves the compressive strength and split tensile strength up to 15% cement replacement.

. • The results encourage the use of Metakaolin, as a pozzolanic material for partial replacement in producing high performance concrete.

V. REFERENCE

[1] Hassan A.A., Lachemi M., Hossain K.M.A. "Effect of metakaolin and silica fume on the durability of self-consolidating concrete." Cement & Concrete Composites 34 (2012) 801–807.

[2] Hajime Okamura and Masahiro Ouchi, Self Compacting Concrete, Journal of Advanced Concrete Technology, Vol.1, No.1, 5-15, 2003.

[3] Kosmas K. Sideris, Christos Tassos, Alexandros Chatzopoulos Production of durable self-compacting concrete using ladle furnace slag (LFS) as filler material. Procediaengineering 108 (2015) 592-597.

[4] M.A.S.Mohamed, E.Ghorbel,G.Wardeh. Valorization of micro-cellulose fibers in self-compacting concrete.construction and building materials 24 (2010) 2473-2480.

[5] Divya chopra, Rafat Siddique, kunal. Strength, permeability and microstructure of self-compacting concrete containing rice husk ash. Biosystem engineering 130 (2015) 72-80

[6] Andreas leemann, Frank winnefeld. The effect of viscosity modifying agent on mortar and concrete.

Sabir B.B, Wild S, Bai J, "Metakaolin and calcined clay as pozzolans for concrete :a review" Cement and concrete composite 23 ,(2001),pp.441-454

[7]. Jian-Tong Ding and Zongjin Li "Effects of Metakaolin and Silica Fume on Properties of Concrete" ACI Materials Journal/July-August 2002,pp.393-398.

[8]. Badogiannis E, Papadakis V.G., Chaniotakis E, Tsivilis S, "Exploitation of poor Greek kaolins: Strength development of metakaolin concrete and evaluation by means of k-value" Cement and Concrete Research 34 (2004),pp.1035–1041.

[9]. Justice J.M, Kennison L.H, Mohr B.J., Beckwith S.L, McCormick L.E, Wiggins B., Zhang Z.Z, and Kurtis K.E, "Comparison of Two Metakaolins and a Silica Fume Used as Supplementary Cementitious Materials" SP-228(Volume1&2) Seventh International Symposium on Utilization of High-Strength/HighPerformance Concrete, June(2005),SP228

[10] Brindra V., Prasannan D., Amutha S., "An Experimental Investigation On Mechanical Properties Of Self Compacting Concrete Containing

Metakaolin", International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 19 (2015), 13763- 13768.

Dynamic Analysis of Machine Foundations Using Abaqus

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Abstract - Machine foundations are one of the most tedious and complicated structures to be constructed as they are subjected to static loadings as well as dynamic loadings. As machine foundations are supposed to sustain the loads and transfer them to the soil, it is necessary that foundations should be properly designed and analyzed. In this paper, the dynamic analysis of machine foundations are done using the Finite Element Method based software ABAQUS. A typical model is analyzed and the results are withdrawn subsequently. Comparative graphs are plotted to compare and analyze parameters under various conditions. Remedial measures are suggested for decreasing the effect of loads.

Keywords: Machine foundation, ABAQUS, Finite Element Analysis, loads.

I. INTRODUCTION

The analysis and design of machine foundation requires cautious attention as it involves dynamic loadings along with the static loadings due to working of the machine. While analyzing the machine foundations, the amplitude and frequency play a very important role in producing the loads as the major dynamic forces are produced due to the periodic oscillations produced due to vibrating machine.
Earlier, the calculations of analyzing the machine foundation involved multiplication of static loads, i.e. vertical loads were multiplied with an estimated dynamic factor and results were withdrawn in the form of increased static load[1]. As a result, serious deformations used to happen during operation of the machine. With modernization in the methods of analyzing such complex problems[2], the results got improved and more accurate. Currently, Finite Element Method is the most widely used method for analyzing the structures subjected to dynamic loadings.
The manual methods of analysis of machine foundation vary according to the types of machine foundations[3], their embedment conditions[3], ground properties[4], amplitude and loading conditions. Various methods used for manual analysis of machine foundations[1] are Linear elastic spring method, Elastic half space analogy method, Arya, Neill and Pincus method.
With evolution in the technology sector, various softwares got developed for analyzing structures. The advantage of using softwares is that it saves time and give more accurate results. Also, the data can be revised or changed at any point. One such softwares is ABAQUS[5,6]. It is an analysis software, based on the Finite Element Analysis method, priorly used for analyzing dynamic problems.

II. NUMERICAL MODELLING

1. Model Details:

The hypothetical case of a block type machine foundation had been considered in this analysis. The foundation was assumed to be resting on cohesionless soil (sand). The boundaries of the soil were considered as 5m long, 5m wide and 5 m deep for the purpose. A periodic oscillation was applied as dynamic loading along with the static loadings over the foundation. The amplitude data was considered in the permissible range confirming to the IS: 2974 – 1982[7]. The study of model had been carried out using the ABAQUS software. In order to achieve the desired objective, the explicit analysis had been done on the model and the values of displacement, velocity and acceleration were obtained at the depths of 0m, 0.5m and 1m below the foundation surface and compared. All the data was analyzed for the time period of 10 seconds for unit time difference.

The dimensions of foundation were considered as 2.5m x 2.0m x 1.0m and it was assumed to be rested above the surface of the soil.

2. Material Details:

For current model, sand was used as the base soil. The soil was assumed to obey the Mohr-Coulomb yield criteria. The shear strength properties and unit weight of soil were obtained from reference books[8], the Young’s modulus and Poisson’s ratio were adopted from Bowles’ theory, the dilatancy angle was considered as per the Baranov’s theory, which implies, $\Psi = \varphi - 30^{o}$, Ψ being the dilatancy angle and φ being the angle of repose.

The detailed specifications are given in the below table (Table No.1).

Table No.1

Material	Material Properties	Unit	Values
	Unit Weight	kN/m^3	19
	Young’s Modulus	kN/m^2	20,000
Soil	Poisson’s Ratio	-	0.3
	Cohesion	kN/m^2	0
	Angle of Repose	Degree (^{o})	32
	Angle of Dilatancy	Degree (^{o})	2
	Unit Weight	kN/m^3	24
Foundation	Young’s Modulus	kN/m^2	2×10^7
	Poisson’s Ratio	-	0.15
Machine	Weight	kN	30

III. RESULTS AND DISCUSSION

The model was analysed for 10 seconds and the values of displacement, velocity and accelerations were obtained for the depths of 0m, 0.5m and 1m below the base of foundation and comparative graphs were plotted.

Figure 1 shows the comparative displacement vs time plot for varying depths. The maximum displacements were obtained as 0.41mm for depth of 0m, 0.31mm for the depth of 0.5m and 0.22mm for the depth of 1m. As per IS recommendations[7], the permissible displacement should be less than or equal to 0.2mm.

FIGURE 1

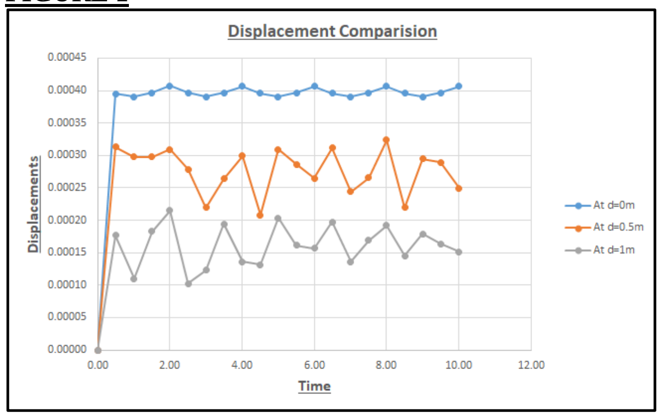


Figure 2 shows the comparative velocity vs time plot for varying depths. The peak velocities were obtained as 1.26mm/s for the depth of 0m, 0.96mm/s for the depth of 0.5m and 0.92mm/s for the depth of 1m. As per the research done by Mulugeta Anteneh[9], the velocity range between 0.51mm/s – 1.02mm/s allows very good operation of machine, the velocity range between 1.02mm/s – 2.03mm/s allows good operation of machine. But for extremely smooth operation of machine, the velocity range should be less than or equal to 0.13mm/s.

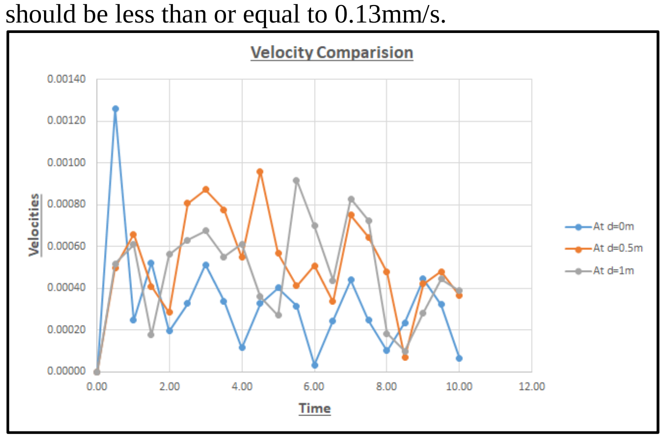
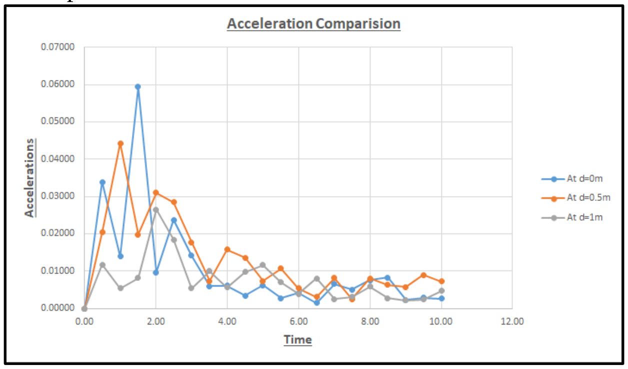


Figure 3 shows the comparative acceleration vs time plot for varying depths. The maximum accelerations

ISBN: 978-93-90214-19-8

were obtained as 59.3mm/s^2 for the depth of 0m, 0.96mm/s for the depth of 0.5m and 0.92mm/s for the depth of 1m.



As the results obtained are exceeding the permissible limits, the foundation assumed is unsafe to carry the loadings. As per the recommendations of IS codes, the values of displacements, velocities and accelerations should be as low as possible. To bring the parameters under permissible values, geosynthetic materials in the form of geocell or geogrid reinforcement can be used. The vibration absorbers can also be used for bringing down the exceeding values. Redesigning the foundation by varying the dimensions or material properties is also one way of bringing values of parameters under limit.

CONCLUSION

1. Machine foundations transmit static and dynamic loads to the supporting soil. In this paper, the analysis of machine foundation subjected to dynamic loadings is presented using the Finite Element Method based software ABAQUS. The paper explores the advantage of using using FEM based software in addition to the classical tables and charts.
2. The paper presents the analysis on the block type machine foundation. The maximum values of displacements, velocities and accelerations obtained show that the foundation is unsafe and preventive measures need to be taken in order to make it safe.
3. Using geosynthetic materials in the form of geocell and geogrid reinforcement, using vibration absorbers are suggested to bring the values within permissible limits or else the foundation needs to be redesigned by varying the dimensions or material properties.

REFERENCES

1. Dynamic Analysis Of Machine Foundation by Piyush K. Bhandari and Ayan Sengupta, International Journal of Innovative Research in Science, Engineering and Technology, Volume 3, Special Issue 4, April 2014.
2. Analysis of machine foundation vibrations: state of the art by George Gazetas, Rensselaer Polytechnic Institute, Troy, New York, USA.
3. Dynamic Analysis of Machine Foundation Using Ansys by P.M. Shimpale , Sindhu Panapalli, M.G.M's College Of Engineering, Nanded, Maharashtra, IJSART - Volume 4 Issue 10 – OCTOBER 2018.
4. Numerical Analysis of Machine Foundation Resting on the Geocell Reinforced Soil Beds by H. Venkateswarlu and A. Hegde, Geotechnical Engineering Journal of the SEAGS & AGSSEA Vol. 49 No. 4 December 2018 ISSN 0046-5828.
5. ABAQUS/CAE 6.11 Software, Theory manual by Dassault Systèmes Simulia Corp., Providence, RI, USA.
6. ABAQUS/CAE 6.11 Software, User manual by Dassault Systèmes Simulia Corp., Providence, RI, USA.
7. IS: 2974 - 1982: Code of Practice for Design and Construction of Machine Foundations.
8. Vibration Analysis and Foundation Dynamics by Kameshwara Rao.
9. Vibration Analysis and Design of Block type Machine Foundations interacting with Soil by Mulugeta Anteneh – March 2003

Understanding Various Structural Analysis Methods for Indeterminate Structures

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Abstract - Indeterminate structures are the structures that can't be statically analysed using equilibrium equations. They indicate that there is at least one more unknown reaction force than there are equations of equilibrium, meaning that the sum of forces and moment in each direction is equal to zero.

Various structural analysis methods are available, some of them give accurate results while some give various errors so therefore parametric values vary among various methods of analysis.

These methods are applied on the basis of equilibrium of forces, compatibility of deformation on joints and supports, etc. for analysis and design process of beam and column.

The structural analysis methods are used to evaluate Bending moment, shear force, reactions, and torsions, etc. which allow the structural designers to design the structural components economically. From the theoretical perspective, the primary goal of structural analysis is the computation of deformations, internal forces, and stresses. For this purpose, we use various methods for the analysis of indeterminate structures.

An effort has been made to understand the intricacies of the steps of calculations in some methods of analysis.

We have taken into consideration the following methods in these process-

1) Kanis Method

2) Moment distribution method

3) Stiffness method

Some literature review indicates that the Moment distribution method and stiffness method are mostly used for the structural analysis.

INTRODUCTION

Structural analysis is the determinant of the effect of loads on physical structures and their components. For designing the structures, it needs various parameter like deflection, displacement, and shear force, bending moment, axial force, and torsion. So for determining these parameters various methods are being used to calculate the bending moment of the indeterminate structure.

In the present study bending moment of the different structures has been taken which will be calculated by various methods of structural analysis.

Following methods of structural analysis are taken into consideration:-

1. Moment Distribution Method.
2. Kani's Method
3. Stiffness Method

METHODS OF ANALYSIS

Moment Distribution Method

The moment distribution method is developed by Hardy Cross. It is the structural analysis method for statically indeterminate beams and frame structures. It was published in an ASCE journal in the year 1930. This method clarifies the flexural effects and ignores axial and shear effects. It is an iterative method in which one goes on carrying on the cycle to reach a desired degree of accuracy.

Initially, all the joints are temporarily restrained against rotation, and fixed end moments for all the members are written down to start off with this method. Every joint is then released separately in succession and the unbalanced moment is distributed to the ends of the members in the ratio of their distribution factors.

These distributed moments will be carried over to the far ends of the joints. After that, the joint is temporarily restrained before moving on to the next joint. The same set of operations are performed at

ISBN: 978-93-90214-19-8

each joint till all the joints are completed and the results obtained are up to the desired accuracy.

The method did not involve solving a number of simultaneous equations otherwise, it will be while quite complicated while applying large structures, and hence this method is preferred over the slope-deflection method.

Kani's Method

Kanis method was developed by Prof. Gasper Kanis of Germany in the year 1947. This method is also called as rotation contribution method. This method involves the distribution of the unknown fixed end moments of the different structural members to satisfy the various conditions of continuity of slopes and displacements of the structures.

This method is a simpler and less time-consuming method compared to the Moment Distribution Method. It gives an approximate calculation method for indeterminate structures, particularly portal frames and multi-story frames with fixed connections.

The frame analysis of the structures is carried out by solving the slope−deflection equations by successive approximations.

This is useful in case of side sway also. Operation is simple because it is carried out in a specific direction.

Stiffness Method

The direct stiffness method is particularly suited for the computer analysis of complex structures including statically indeterminate structures. This method is also known as the matrix stiffness method. This method is the most common implementation of the finite element method (FEM). This method makes use of the members' stiffness relations while computing member forces and displacements in structures.

Through stiffness method mathematics, the material stiffness properties of these elements are compiled into a single matrix equation which conducts the behaviour of the entire structure.

The unknown displacements and forces of the structures can then be determined by solving the equations

REVIEW OF LITERATURE

Arnulfo Luevanos Rojas discussed that the methods of analysis of statically indeterminate beams, using shear deformations, which is an extension to the moment distribution method, which is used to analyse all kinds of continuous beams. This methodology considers shear deformation and flexure. After analysing he found that the moment-distribution method (considering shear deformations), happens to be the more appropriate method for structural analysis of continuous beams and also more attached to the real conditions. [1]

A.Samuelsson (2006) presents a brief history of the development of the stiffness method. He starts by tracing the evolution of the method to solve discrete-type problems such as trusses and frames composed of two-node members. Then they describe the method as it is applied to solve continuum problems modelled by finite-difference and finite-element methods. In the paper, they conclude that the main steps in the development of the stiffness method from its birth in the 1820s as a method for analysis of statically indeterminate bar structures with joint displacements as unknowns. [2]

R. H. Mohankar has worked out the analysis of portal frames involving various complications and calculations by conventional methods. They present the analysis of portal frame, considering mainly the case The Kani's method is self-correcting, that is, the error, if any, in a cycle is corrected automatically in the subsequent cycles. The checking is easier as only the last cycle is required to be checked of the single bay portal frame, which is the most common in practice. The convergence is generally fast. It leads to gives the solutions in just a few iterations cycle. [3]

Dipak J. Varia presented a parametric study of an Innovative approximate method of a continuous beam. Structurally a building may consist of load-bearing walls and floors. The floor slabs may be supported on beams which in turn may be supported on walls or columns. But, for a multi-storeyed structure a building frame either of steel or of reinforced concrete is made. His study gives an introduction to the newly developed Relative Deformation Coefficient Approach. [4]

ISBN: 978-93-90214-19-8

Ankush Kumar Jain presented the analysis of continuous beam, there are many complexities and monotonous calculations involved in traditional methods. Bending moment is one of the important parameters from the structure design point of view. In their present investigations to calculate bending moment four different methods i.e. slope deflection, moment distribution, Kani's method, and stiffness matrix method, these methods have been applied for the analyses of the continuous beam.
This study reveals that the Bending moment obtained from these methods has the nearly same value. The results obtained from the moment distribution method are quite accurate because the number of iteration performed in the moment distribution method is comparatively more. [5]

Prajapati Viraj Rakeshkumar has investigated the comparison of different structural analysis methods using the continuous beam. For the design of any structure, a bending moment is a key parameter in this Slope deflection, Kani's, Moment Distribution used for the analysis of the taken indeterminate continuous beam. Conducted study of this literature shows the value of bending moment in an above Slope deflection, Kani's, moment distribution nearly similar but the Moment distribution method gives more accurate values.
They conclude that the Moment Distribution Method is most accurate because the number of iterations is more comparatively. [6]

PROBLEM ANALYSIS

Analyse the given beam by Moment Distribution Method (MDM), Kani's Method & Stiffness Method.

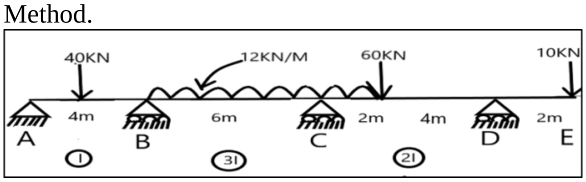

Fig.1

Result
After analysing the given beam structure problem by three methods which are-
1. Moment Distribution Method (MDM)
2. Kani's Method
3. Stiffness Method

We get the final bending moment which is shown in table no.1 given below.

Sr. No.	Bending Moments at Member	Stiffness Method [KN-m]	Kani's Method [KN-m]	Moment Distribution method(MDM) [KN-m]
1	AB	0	0	0
2	BA	29.72	29.754	29.724
3	BC	-29.72	-29.87	-29.721
4	CB	49.66	50.40	49.65
5	CD	-49.66	-49.29	-49.65
6	DC	20.0	20.04	20.04

(Table no.1)

Percent Variation in values with respect to Stiffness Method:-

Sr. No.	Member	Moment Distribution Method (MDM) (%)	Kani's Method (%)
1	AB	0	0
2	BA	0.01	0.11
3	BC	0.50	0.003
4	CB	1.49	0.02
5	CD	0.02	0.74
6	DC	0.2	0.05

(Table no.2)

Analyse the given frame by Moment Distribution Method (MDM), Kani's Method & Stiffness Method.

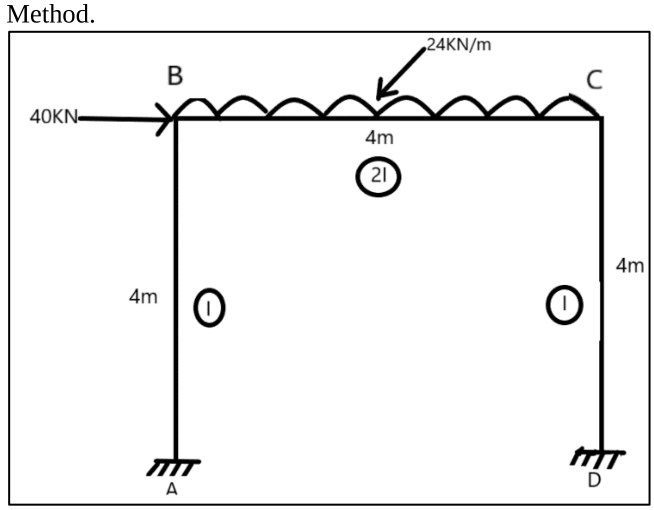

Fig.2

ISBN: 978-93-90214-19-8

Result: - After analysing the given frame structure problem by three methods which are-

1. Moment Distribution Method (MDM)
2. Kani's Method
3. Stiffness Method

We get the final bending moment which is shown in table no.3 given below.

Sr. No.	Bending Moments at Member	Stiffness Method [KN-m]	Kani's Method [KN-m]	Moment Distribution method(MDM) [KN-m]
1	AB	-35.08	-35.032	-35.01
2	BA	-20.92	-20.79	-20.85
3	BC	20.92	20.80	20.86
4	CB	52.92	52.87	52.88
5	CD	-52.92	-52.79	-52.85
6	DC	-51.08	-50.92	-50.99

(Table no. 3)

Percent Variation in values with respect to Stiffness Method:-

Sr. No.	Member	Moment Distribution Method (MDM) (%)	Kani's Method (%)
1	AB	0.19	0.14
2	BA	0.33	0.62
3	BC	0.28	0.57
4	CB	0.075	0.09
5	CD	0.13	0.24
6	DC	0.313	0.19

(Table no.4)

CONCLUSION

The analysis of this problem has been carried out by the Moment Distribution Method, Kanis Method, and Stiffness Method.

The result indicates that the variation in bending moment at different points doesn't vary much. However, with respect to the stiffness method the percentage variation as given in table no.2 & table no.4 Thus, it is calculated that the stiffness method of analysis is mostly used in computer software.

This method is specially used for the analysis of structures.

REFERENCES

Arnulfo Luevanos Rojus and Roman Luevanos Rojas, " The moment distribution method for Statically indeterminate beams considering the shear deformation", International Review Of Civil Engineering -2011

A. Samuelsson, O. C. Zienkiweicz, " History of stiffness", International Journal Of Numerical Method In Engineering -2006

P. R. Patil, M. D. Pidurkar, R. H. Mohankar, "Comparative Study of End Moments Regarding Application of Rotation Contribution & Moment Distribution Method for the Analysis of Portal Frame", IOSR Journal of Mechanical and Civil Engineering, Issue-1 (IOSR-JMCE) May - Jun 2013

Dipak J. Varia, Dr. Harshvadan S. Patil, "Comparative study of classical method and relative deformation coefficient approach for continuous beam analysis", International Journal Of Civil Engineering And Technology -2015

Ankush Kumar Jain, "Analysis of a continuous beam by using different structural analysis methods", International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 09 | Sep -2017

Prajapati Viraj Rakeshkumar, "Comparison of Different Structural Analysis Method using Continues Beam", International Research Journal of Engineering and Technology (IRJET) Volume: 06 Issue: 09 | Sep -2019

Structural Analysis Book by L. S. Negi and R. S. Jangid

Structural Consideration for Building on the Sloping Ground

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Abstract - In the past Few years, some new methods have been adopted to make multistory building laterally strong and stable by application of structural elements specially for high rise multistoried buildings and which are subjected to various challenges like high wind velocities, earthquake zones in hilly areas etc. A shear wall is one of them which are a structural member which provides lateral stiffness and strength to the structure. The earthquake can be even more hazardous on sloping land. Exponentially increasing urbanization in the hilly region have accelerated the development in real estate sector due to this population density in the hilly region which is increasing rapidly. Therefore, there is popular demand for construction of the Multistoried structures on a hill slope in and around the cities. A scarcity of evenly fair ground in hilly area pushes Engineers to work and advance the construction activity on slopping ground with provision of safety in worst condition too. Hill building constructed in masonry with mud mortar/cement mortar are not satisfying the codal provision requirements, hence ultimately have proved unsafe and, resulting in the loss of life and properties when subjected to earthquake motions.

Therefore, it is mandatory to Provide earthquake resisting Techniques or systems to make structure sound and stable so basically in this Literature Review paper we will be discussing the various research papers which provided the solution and methods to ensure safety and stability of building in earthquake zone area as well as hilly regions having scarcity of evenly fair ground..

Keywords: Shear wall, Economic growth, Urbanization, earthquake, Multistoried building, STAAD PRO.

INTRODUCTION

In developing country like India, industries are growing rapidly everywhere in the country. Growth and rapid urbanization in the hilly region have accelerated the real estate development due to population density in the hilly region that increased enormously. A scarcity of plain ground in hilly area compels the construction activity on slopping ground.

While constructing the multistoried building on slopping ground, it is important to consider the natural calamities factors like earthquake, wind forces and also uneven settlement loads, in addition to the weight of structure and occupants, create bending and twisting forces on the high-rise buildings. To overcome such situation, Shear wall plays vital role to maintain stability and rigidity of multistoried structure by positioning them in proper manner.

LITERATURE REVIEW

The study of papers is done as mentioned below and the particular conclusion or result found by the authors are mentioned itself in Papers summary provide below-

1. Ankit Dane, Umesh Pendharkar has done research work on Effective Positioning of Shear Wall in G+5 Storey Building on Sloping Ground.as To Determine the Effective Location of shear wall in the multistory building built on sloping ground. (For that purpose, four different models have been taken. Modal one is conventional rigid frame building and the remaining three models are kept with the shear study concludes that when the shear walls are applied toward the upward slope side, it works effectively. When shear walls were placed on upward slope side location, a huge difference has been seen between the story shear of the first and second story which can induce the diagonal shear failure on the short-column side. That's why the second nearest location to upward

side will be considered as the optimum location of the shear wall.

2. S.P. Pawar and Dr.C.P.Pise has done work on effect of positioning of rc shear walls of different shapes on seismic performance of building resting on sloping ground and concluded that The straight shape (or rectangular) shear walls configuration proves to be better among all configurations for resisting the lateral displacement. The L-shape shear walls configuration is effective during seismic activity because the member forces developed in this configuration are less as compared to other configurations on sloping ground whereas on plane ground this configuration has approximately same member forces for all configurations. Also, for this configuration base shear is Minimum among all configurations on leveled ground. Use of T-shape shear walls gives more lateral displacement and member forces for buildings on slopes as compared to other configurations.

3. Sachin Kumar Dangi and Saleem Akhtar has done the seismic behavior of RC buildings on sloping ground is analyzed; considering the G+6 storey frame geometries with shear wall and without shear wall at different slopes. The modeling and analysis are done with the help of STAAD Pro v8i. The objectives of the study are as follows: To analyze 3-D building with shear wall under seismic load on different slopes i.e., 15, 30 and 45. To study the variation of shear force, bending moment, axial force and Node displacement at different slopes. To compare the behavior of RC building with shear wall and without shear wall on sloping ground. To find the better location of the shear wall. And found that There is significant improvement observed in seismic performance of building on sloping ground by providing shear walls with different configurations since lateral displacement and member forces reduce considerably in building due to provision of shear walls. It is observed that maximum displacement is found in case of 45° slope without shear wall. Hence we can say that, risk increases with the inclination of the slope. In this study we found that, the position of the shear wall at periphery is the optimum position for the lateral load resistance. It is observed that, the position of the shear wall at corner is the optimum position for countering axial loads. It is observed that, maximum shear force and maximum bending moment increase significantly for sloping ground at 45° slope. It is observed that, axial force increases in the buildings with shear wall. Base shear is found maximum in the building with shear wall, due to dead load of the shear wall.

4. Sripriya Arjun, Arathi S has done research on A Study on Dynamic Characteristics of RC Buildings on Hill slopes in this study, behavior of G+3 storied sloped frame building having step back set back configuration is analyzed for sinusoidal ground motion with different slope angles i.e., 16.7°, 21.8°, 26.57° and 30.96° using structural analysis tool STAAD Pro. by performing Response Spectrum analysis have been carried out as per IS:1893 (part 1): 2002. The results were obtained in the form of top storey displacement and base shear. It is observed that short column is affected more during the earthquake. The analyses showed that for construction of the building on slopy ground the step back setback building configuration is suitable.

5. S K Hirde and N K Shelar has research on Effect of Positioning of RC Shear Walls on Seismic Performance of Buildings Resting on Plain and Sloping Ground. in this study the attempt is made to analyze the multistorey buildings on plain and sloping ground with and without shear walls. The performance of the building with various configurations of shear walls such as straight, L shape, T shape and channel shape is studied. For all shear walls configurations under considerations the length of shear wall in two principal directions in plan is kept equal. The RCC building models having

G+6 storeys with shear walls and without shear walls resting on plain and sloping ground (slope 1V:2.33H) are considered for the study. The response spectrum analysis of building is carried out using structural engineering software SAP 2000 V 15.2.2 and the seismic performance of building with various shear walls configurations is compared with respect to parameters like base shear, lateral displacement, time period and member forces.

6. Gagandeep and Aditya Kumar Tiwari has done research work on Analysis of Asymmetrical Building with Shear Wall under Seismic Loading and gave results that Due to presence of shear walls

in the external frame of the building, the axial forces in the columns were reduced by 10-15%, in internal column there was a marginal reduction of 2-4%. The shear force was reduced by 10-80% for columns in the lower storeys, and then increased by 50-100% for columns in the top storeys. The bending moment reduced by 10-80% for the columns in lower storeys, but it increased from 15-50% from 6th to top storey.

7. Sandip Doijad, Surekhabhal Chandra has done research work on Seismic Behavior of RC Buildings Constructed on Plain and Sloping Ground with Different Configuration of Shear Walls. Had objectives as to study seismic behavior of building with and without shear wall resting on plain and sloping ground. To study the effectiveness of different shear wall configurations on seismic performance of building resting on plain and sloping ground such as straight and angular shape. (9°,18°,27°). To suggest efficient shape of shear wall for building resting on sloping ground for its better seismic performance then concluded that There is significant improvement observed in seismic behavior of building on plain as well as sloping ground by incorporation of shear wall. Since fundamental time period, floor displacement and member forces reduce considerably. Base shear of building increases due to provision of shear wall in both X and Y direction on plain and sloping ground. The straight shape shear wall proves to be better among both configurations for resisting lateral forces.

8. S. Praveen kumarG., Augustine, Maniraj Pandian has done research on Analysis and Evaluation of Structural Systems with Bracing and Shear Wall. with objectives as To identify the suitability for strengthen techniques for lateral load resistance between bracing and shear wall with respect to increase in the height of building(G+19).and concluded that Storey drift of the Shear wall and steel braced model is within the limit as clause no
7.11.1 of IS-1893 (Part-1):2002.but shear wall has more value as compared to bracing From the results of G+19 models, the top storey displacement of X-Braced model is 5.59% lesser than shear wall model. Therefore, it's recommended to provide bracing for buildings more than 15 storeys.
Comparing the cost, bracing is 30.1% higher than shear wall for one panel.

9. Tarun Magendra, Abhyuday Titiksh and A.A. Qureshi has done research work on Optimum Positioning of Shear Walls in Multistorey Buildings. they concluded that the frame with Shear Walls clearly provides more safety to the designers and although it proves to be a little costly, they are extremely effective in terms of structural stability. Due to the falling of the zone, the earthquake hazard will also increase. In such cases, use of shear walls becomes mandatory for achieving safety in design.

10. Anwarul Haque, Dr. Shobha Ram has done research on Study on Seismic Analysis of Buildings With RC Shear Wall And Composites Shear Wall. And has an objective To compare RC shear wall and Composite shear wall provided at different locations of the building. To study the behavior of building for regular plan under seismic loads and load combinations as per IS 1893:2016. To evaluate the response of RC multi-storeybuilding (G+25) with RC shear wall (RSW)and Composite shear wall (CSW). To determine seismic parameters that are time period, mode shape, base shear, storey shear, storey displacement, storey drift, stiffness.

11. Jaimin Dodiya, Mayank Devani, Akash Dobariya, Mehul Bhuva, Kamalsinh Padhiar has done analysis on multistory building with shear wall using etabs software. they concluded that In the present work the lateral structural system i.e., shear wall system considered for 20 story structure. Conclusions that can be made from the above study is by comparing the different location of shear wall in multi-story building. Form the study it is clear that gives less displacement value in opposite direction in shear wall building for moderate seismic zone. Providing shear wall at opposite direction performing better and more efficient than all other cases.

12. B.G. Birajdar, S.S. Nalawade has studied and research on seismic analysis of buildings resting on sloping ground and summoned that Results from seismic analyses performed on 24 RC buildings with three different configurations like, Step back building, Step back Set back building and Set back building are presented. 3 –D analysis including torsional effect has been carried out by using response spectrum method. The dynamic response

properties i.e., fundamental time period, top storey displacement and, the base shear action induced in columns have been studied with reference to the suitability of a building configuration on sloping ground. It is observed that Step back Set back buildings are found to be more suitable on sloping ground.

13. V.V.B.L.N.D. Vara Prasad, Mrs T. Sujatha, Mrs J. Supriya has done research work on Optimum Location of a Shear Wall in High Rise U-Shape Building and they concluded that - The shear wall and it is position has a significant influenced on the time period. Time period is not influenced by type of soil and Base shear is effected marginally with placing of shear wall , grouping of shear wall and type of soil. The base shear is increasing by adding shear wall due to increase in seismic weight of the building also the Provision of shear wall generally results in reducing the displacement because the shear wall increases the stiffness of building.

14. Syed Ehtesham Ali and Mohd Minhaj Uddin Aquil has done study on Study of Strength of RC Shear Wall at Different Location on Multi-Storied Residential Buildings to achieve maximum rigidity and stability to the structure which also proves to be economical. They compared the 4 types of models of various location of shear wall and gave the comparing results in terms of strength, stability, shear force, bending moment on various levels of structure.

15. Renu Mishra and A. K. Dwivedi has reviewed Symmetrically and Non-Symmetrically Pattern of Shear Walls and gave the conclusions such as Shear wall is very effective in resisting horizontal forces in multistory structure. If shear wall is located properly, then it will reduce shear force, bending moment, and also reduces storey displacements. Most effective location of shear wall is at the outer periphery of building as a core in plan. It significantly reduces the axial force, shear force, moment and also displacement. The shear wall located symmetrically at the center of plan as core is a good option for balance between cost and reduction in member forces and lateral displacements. Unsymmetrical shear wall configurations i.e., C, L or other type's core shear walls which are placed asymmetrically in plan produces torsion which also increases forces and displacements in some of the members.

SUMMARY OF LITERATURE REVIEW

After reviewing the papers included in this literature review the overall general summary is given in some Important points as mentioned below-

- when the shear walls are applied toward the upward slope side, it works effectively.
- The straight shape (or rectangular) shear walls configuration at the core position proves to be better among all configurations for resisting the lateral displacement.
- The L-shape shear walls configuration is effective during seismic activity among T, U and straight wall shape.
- Use of T-shape shear walls gives more lateral displacement and member forces for buildings on slopes as compared to other shapes.
- More the Angle of Slope on which structure will be situated more vulnerable will be the results in terms of stability and soundness of structure.so basically inclination compromises the stability of building when subjected to adverse conditions.
- Provision of shear wall will result into increase into dead load of structure which will ultimately increase base shear of building.
- Comparing the cost, bracing is 30.1% higher than shear wall for one panel. So basically, Bracing Proves to be effective up to certain height as compared to shear wall.
- Composite shear wall proves to be effective in terms cost as well structural stability in multistoried. So composite shear wall is superior as compared to RC shear wall in a structure.
- In comparison with shear wall and bracings (X shaped), the bracing Proves to be economical after particular Height. So depending upon the height of building we should insert lateral stability components as per the requirements with consideration of economy and safety of structure.

REFERENCES

[1] Ankit Dane, Umesh Pendharkar, "Effective Positioning of Shear Wall in G+5 Storey Building on Sloping Ground" International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-9 Issue-2, December, 2019

[2] S.P. Pawar and Dr.C.P. Pise, "effect of positioning of rc shear walls of different shapes on seismic performance of building resting on sloping ground", Volume 7, Issue 3, May–June 2016, pp. 373–384,
Article ID: IJCIET_07_03_038
[3] Sachin Kumar Dangi and Saleem Akhtar," Seismic Analysis of a RC Building on Sloping Ground with Shear Wall at Different Positions", AIP Conference Proceedings 2158, 020030 (2019); https://doi.org/10.1063/1.5127154 Published Online: 25 September 2019.
[4] Sripriya Arjun, Arathi S," A Study on Dynamic Characteristics of RC Buildings on Hill slopes", International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391
[5] S K Hirde† and N K Shelar," Effect of Positioning of RC Shear Walls on Seismic Performance of Buildings Resting on Plain and Sloping Ground", E-ISSN 2277 – 4106, P-ISSN 2347 – 5161 10 May 2015, Available online http://inpressco.com/category/ijcet 15 May 2015, Vol.5, No.3 (June 2015)
[6] Gagandeep and Aditya Kumar Tiwari, "Analysis of Asymmetrical Building with Shear Wall under Seismic Loading", International Journal of Engineering Science Invention (IJESI) ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org ||Volume 7 Issue 6 Ver III || June 2018 || PP 13-20
[7] Sandip Doijad, Surekhabhal Chandra, "Seismic Behavior of RC Buildings Constructed on Plain and Sloping Ground with Different Configuration of Shear Walls.", Journal of Civil Engineering and Environmental Technology Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 10; April-June, 2015 pp. 59-65 © Krishi Sanskriti Publicationshttp://www.krishisanskriti.org/jceet.html
[8] S. Praveen kumarG., Augustine, Maniraj Pandian, "Analysis And Evaluation Of Structural Systems With Bracing And Shear Wall", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 04 | Apr-2016 www.irjet.net p-ISSN: 2395-0072
[9] Tarun Magendra, Abhyuday Titiksh and A.A. Qureshi," Optimum Positioning of Shear Walls in Multistorey Buildings", International Journal of Trend in Research and Development, Volume 3(3), ISSN: 2394-9333
[10] Anwarul Haque ,Dr. Shobha Ram, "Study On Seismic Analysis Of Buildings With RC Shear Wall And Composites Shear Wall", International Journal of Engineering and Techniques – Volume6 Issue 3,June 2020.
[11] Jaimin Dodiya, Mayank Devani, Akash Dobariya , Mehul Bhuva , Kamalsinh Padhiar- ,"analysis of multistory building with shear wall using etabs software", e-ISSN: 2395-0056 Volume: 05 Issue: 02
| Feb-2018 www.irjet.net p-ISSN: 2395-0072
[12] B.G. Birajdar , S.S. Nalawade," seismic analysis of buildings resting on sloping ground", 13th World Conference on Earthquake Engineering Vancouver,
B.C., Canada August 1-6, 2004 Paper No. 1472
[13] V.V.B.L.N.D. Vara Prasad, Mrs T. Sujatha, Mrs J. Supriya-, "Optimum Location of a Shear Wall in High Rise U-Shape Building", International Journal of Engineering Research & Technology (IJERT)
Vol. 3 Issue 8, August – 2014
[14] Syed Ehtesham Ali, Mohd Minhaj Uddin Aquil "Study of Strength of RC Shear Wall at Different Location on Multi-Storied Residential Building", Syed Ehtesham Ali Int. Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 4, Issue 9(Version 5), September 2014, pp.134-141
[15] Renu Mishra and A. K. Dwivedi "Symmetrically and Non-Symmetrically Pattern of Shear Walls" IJIRST –International Journal for Innovative Research in Science & Technology| Volume 2 | Issue 12 | May 2016 ISSN (online): 2349-6010

Experimental Analysis of Flexible Pavement Structure Using Waste Plastic: A Review

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Abstract - This paper mainly deals with providing a sustainable and a pro-environmental measure to construct a flexible pavement using thermoplastic modifiers, namely High density polyethylene (HDPE) and Low density polyethylene (LDPE) into the conventional VG 30 grade bitumen sample in different percentage so as to find the proper percentage of blend so as to provide a pavement of good quality with minimal or no maintenance cost and also to reduce the cost of construction and maintain an economy by reducing the percentage of bitumen by replacing it with plastic in shredded form. It also helps in managing a way for disposal of solid waste, particularly Plastic waste and to meet the MDG. Using of waste plastic such as HDPE or LDPE in shredded form has proven to show promising results both for the environment as well as the pavement construction in term of providing better riding quality and increase in Marshal stability value and reduction in flow value as compared to conventional bitumen sample.

Keywords: Thermoplastic modifiers, HDPE, LDPE, PET, etc.

INTRODUCTION

A well-developed infrastructure can bring prosperity to a region, an absence of adequate infrastructure can push any region towards poverty. Well-developed infrastructure demands proper connectivity and transport facility among the regions for transport of passengers and frights with minimal cost. This paper forms a part of a research to solve two main problems: firstly, the need for a sustainable transport system with low maintenance cost and secondly, to curb the problem of solid waste disposal by using waste plastic in road construction. With increase in demand and reliability on the road transport facility and connectivity there arises a need for good quality roads to sustain heavy traffic and very high axle loads. To curb this demand there is a constant search for durable and good quality roads with low maintenance cost and high performance index.

Using Waste Plastic in road construction is a sustainable way to fulfill this demand and also to tackle the problem of plastic waste disposal. The inclusion of thermosplastic modifiers to virgin bitumen sample is known to improve the viscoelastic behaviour of the bitumen and also improves the overall rheological properties of the sample.

LITERATURE REVIEW

Safeer Haider, Imran Hafeez et.al (2019) The author's work was based on physical and chemical properties of the aggregate and their influence over the performance of the asphalt mixtures. According to the work carried out the author concluded that aggregate quarries with high polar, hydrophobic and basic nature of aggregates have relatively strong adhesion properties. Aggregate quarry containing granite minerals was more susceptible to moisture damage due less polarity, hydrophilic and acidic nature of aggregates. In modifiers, high density polyethylene (HDPE) is less sensitive to moisture damage. However, low density polyethylene (LDPE) also enhances the performance properties of asphalt mixtures. In mixing methods, wet method of mixing was found relatively better than dry method of mixing.

D.Movilla-Quesada, A.C. Raposeiras et.al (2019) The author favors the dry method of mixing over wet method with a view that the manufacturing process is controlled. The dry method is even favourable because allowing the use of an approximately one to two tons of plastic scrap per kilometre, assuming a 5-cm-thick paved surface layer with two lanes. The amount of asphalt binder in the manufacture of the mixture can be reduced by about one ton. The amount of plastic scrap used and binder saved per kilometre could be increased if the material is also used in lower layers of the pavement (base and binder layers), which have lower requirements for strength and moisture damage resistance and are built with greater thickness than the surface layers, generating a more significant reduction in the environmental impact of the construction of this type of pavement.

Vishal Rasal, L Nokfho K, P.M.Wale, Mrunalini Kasar, et.al (2018) The authors carried out the research using a combination of HDPE and crumb rubber along with conventional bitumen mixes. The aggregates were coated with 6%, 8%, 10% of high density polyethylene and 8%, 10%, 12% of crumb rubber were mixed in bitumen. Different moulds were prepared with different combinations and compared with conventional bitumen mixes by conducting marshall stability test to check its strength, flow value, stability value. Optimum percentage of crumb ru bber was found to be 8%. Then crumb rubber percentage is kept constant and HDPE percentage is varied as 6%, 8%, 1 0% Highest stability is achieved for all mix with 8% CRMB combination with 10% of HDPE giving more satisfied res ults comparing to conventional bitumen.

Manju Anand and Sathya. S (2017) The waste plastic used by the authors are poly-ethylene, poly-styrene, poly-propylene. According to the author plastic mixed with bitumen and aggregates is used for the better performance of the roads. The polymer coated on aggregates reduces the voids and moisture absorption. This results in the reduction of ruts and there is no pothole formation. The plastic pavement can withstand heavy traffic and are durable than flexible pavement. The use of plastic mix will reduce the bitumen content by 10% and increases the strength and performance of the road. This new technology is eco-friendly.The use of smoke absorbent material (titanium di-oxide) by 10% of polymer content can reduce the vehicular pollution.

Ahmad M. Abu Abdo (2017) The author investigated two different Superpave mixes with 0%, 0.2%, 0.5%, and 1% plastic waste of aggregates weight were investigated. 3D Move Analysis software was utilized to determine rutting depths and top down and bottom up cracking in a typical asphalt concrete layer with the different plastic waste contents at various temperatures. Results showed that adding 0.2% plastic waste to HMA would enhance the performance of these mixes. Also, mixes with 0% (control) and 0.5% plastic waste performed similarly. However, when adding 1% plastic waste, mixes performed poorly. Based in these results, utilizing 0.5% plastic waste by weight of aggregates in HMA would make flexible pavement design eco-friendlier and more sustainable, since a big amount of plastic waste could be incorporated without effecting the performance of hot mix asphalt.

Johnson Kwabena Appiah, Victor Nana Berko-Boateng, et.al (2016) The authors carried out the research using High Density Polyethylene (HDPE) and Polypropylene (PP) in Conventional AC- 20 graded bitumen, at various compositions. It was observed that the polypropylene polymer, showed profound effect on homogeneity and compatibility with slight linear increment in the viscosity, softening and penetration values as against relatively high change for HDPE modified bitumen. The most compatible and incompatible blends for HDPE were respectively observed at 2% and 3% polymer loading. The most enhanced, homogeneous blend is achieved with PP at 3% polymer loading.
Also, FTIR spectroscopy was also employed to study the chemical functionalities present in the bitumen composite. The properties of unmodified bitumen were found to be enhanced with the changes recorded in the rheological properties of the polymer modified bitumen (PMB).

Amit Kumar Sahu , R. K Singh (2016) The author carried out the research work and used the concluded result on the 5m metal road proposed in the premises of Parthivi College OF Engg. & Mgmt. The author concluded that the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. This technology not only strengthened the road construction but also increases the road life. According to the author the use of higher percentage of plastic waste reduces the need of bitumen by 10%. The author further mentions in compliance with the expected results we can ignore the cavities, unsoundness and water accumulation on the roads and make the roads durable and of higher compressive strength along with abrasion resistant in an affordable and cost-effective manner.

Brajesh Mishra Assistant Engineer, U.P. Cane Development Department, Lucknow (2016) According to the work undertaken by the author the experimental evidences and the amount of raw materials used for 20 mm thick Bituminous Premix carpet (top layer of the bituminous road) with type-A seal coat. One Kilometer long road having width 3.75 meter (3750 M²) the following calculation has been arrived –

Material needed Qu	antity of bitumen with conventional aggregate	antity of bitumen with Plastics coated aggregate (PCA)
VG-30 Bitumen	9150Kg	8326 Kg
Plastic waste	Nil	824 Kg
Cost	Rs 549000	(Bitumen)Rs 499560+ (Plastic) Rs 8240 = Rs 507800
Cost Reduced (per KM) for Single lane road having width 3.75 Meter	Nil	Rs 41200

Table - Economy of Process

Cost of Bitumen Approx: Rs 60 per Kg and Waste Plastic : Rs. 10 per Kg (Cost of waste plastic Rs 6 per Kg and Cost of processing Rs 4 per Kg)

Savings of bitumen = 824 kg. Use of Plastic waste = 824 kg
Cost Reduced (per KM) for single lane road having width 3.75 Meter = Rs 41200

The author concluded that there is no maintenance cost for a minimum period of five years. Hence the process is cheap and eco- friendly.

Silvia Angelone, Marina Cauhape´ Casaux et.al (2015) The author used Polyethylene from silo bags in the form of flakes (SBF)of size 6 and 10 mm and pellets (SBP)with sizes 2 and 5 mm, the other type of material been used was recycled Polypropylene chip(PPC). The Marshall Quotient (MQ) obtained is of the similar order of magnitude as in the conventional asphalt cement CA30 mixture for SBF and SBP. However, PPC mixtures have lower MQ, approximately 40 % of the CA30 value. They also conducted indirect tensile test which indicated that SBF and PP ones have lower tensile strength and SBP ones have similar values. Fracture energy (FE) is higher for SBF and SBP mixture and lower for PP ones than the control ones. The author concluded that addition if RPE from silo bags improves the mixture performance over the control mixture. Flakes form was slightly better than pellet ones.

Dr. Hamed M. Jassim, Omar T. Mahmood (2014) The author recommended proportion of the added plastic waste upto (15% by weight of aggregate) that can be used for construction of road pavement to improve the Marshal stability and moisture resistance. Using thick particles of plastic waste in asphalt mixture, decrease the Marshall stability and increase moisture susceptibility as compared with using the thin particles. Finally, the conclusion of this study, that the added plastic waste to the asphalt mixture with fine particles size (passing sieve No.16 (1.18mm)), thin thickness (0.2mm), and (15% by weight of aggregate), increase the Marshall stability and the index of retained strength by (20% and 15%) respectively more than the conventional mix.

Shiva Prasad K, Manjunath K. R, et.al (2012) The author's aim was to investigate the effects of waste plastic bottles on the strength and stability characteristics of BC mix which is used for surface course in road construction. The author concluded that:

The optimum plastic content for 60/70 and 80/100 grade bitumen was 8%.

 ISBN: 978-93-90214-19-8

For both 60/70 and 80/100 grade bitumen with plastic content 8%, the maximum stability was achieved in 80/100 grade bitumen.

Wet process i.e. blending of plastic and bitumen cannot be carried out due to the plastic which is used has a very high melting point.

There is an increase in stability up to 15% and 10% after adding waste plastic to the mix in 60/70 and 80/100 grade bitumen respectively.

Biswanath Prusty, NIT Rourkela (2012) The author says polymer modified pavements would be a boon for India’s hot and extremely humid climate, where temperatures frequently rises past 50°C and torrential rains create havoc, leaving most of the roads with heavy distresses. According to the research work carried out by it was concluded that the Marshall stability value of the prepared sample increases with polyethylene content upto 4% and thereafter decreases. In the modification process plastics-waste is coated over aggregate this increases the surface area of contact at the interface and ensures better bonding between aggregate and bitumen. The polymer coating also reduces the void spaces present in the mix. This prevents the moisture absorption and oxidation of bitumen by entrapped air. The road can withstand heavy traffic and show better service life.

R.Vasudevan, A. Ramalinga Chandra Sekar et.al (2012) The author R. Vasudevan also called as the “The Plastic Man”has also got patent on the dry method of asphalt mix. The author believes value to the dry process as this process helps to dispose 80% of the waste polymers usefully by an eco-friendly method. This has already been accepted by the Central Pollution Control Board, New Delhi. By the dry process, which is in-situ, waste polymer like carry bags, foam, laminated sheets, cups are all used for road laying. Moreover, the use of polymers helps to reduce equivalent quantity of bitumen, thus reducing the cost of the road laying. The studies on the performance of plastic tar road conclusively proves that it is good for heavy traffic due to better binding, in- creased strength and better surface condition for a prolonged period of exposure to variation in climatic changes Above all, the process helps to dispose waste plastics usefully and easily.

Al-Hadidy , Tan Yi-qiu (2009) The author investigated the potential use of pyrolysis low density polyethylene (LDPE) as a modifier for asphalt paving materials.Five different blends including conventional mix were subjected to binder testing such as rheological tests, as well as to some other tests related to the homogeneity of the system. Further, its effect on the moisture sensitivity and low temperature performance of stone matrix asphalt (SMA) mixtures was studied. Research results indicate that modified binders showed higher softening point, keeping the values of ductility at minimum range of specification of (100+ cm), and caused a reduction in percentage loss of weight due to heat and air (i.e. increase durability of original asphalt). The results indicated that the inclusion of LDPE in SMA mixtures can satisfy the performance requirement of high-temperature, low temperature and much rain zone.

Hinislioglua and Agar The author investigated the possibility of modified bituminous binders using various plastic wastes containing high density polyethylene (HDPE) in different percentages and use them in an asphalt concrete. Binders used in hot mix asphalt (HMA) were prepared by mixing the HDPE in 4, 6 and 8 % (by weight of optimum bitumen content) and AC- 20 at temperatures of 145, 155 and 165 °C and 5, 15 and 30 min of mixing time. They concluded that the mix with 4 % HDPE, mixed at 165 °C for 30 min has the highest stability and the smallest flow, and so the highest Marshall quotient (MQ). Moreover, this mix was also highly resistant to permanent deformation (rutting). Hence, they obtained pavements more resistant to permanent deformation as well as a partial solution to solid waste disposal problem.

V. S. Punith, A. Veeraragavan (2007) The author has used reclaimed polyethylene (PE) derived from low-density PE carry bags collected from domestic waste as an additive in asphalt concrete mixtures.The analyses of test results show that the performance of PE-modified asphalt mixtures are better when compared to conventional mixtures. The rutting potential and temperature susceptibility can be reduced by the inclusion of PE in the asphalt mixture. A PE content of 5% by weight of asphalt is recommended for the improvement of the performance of asphalt concrete mixtures similar to that investigated in this study.

CONCLUSION

In the present scenario of world pandemic when every country is struggling with their economy being hit hard, so there is a need to use every resource sparingly without compromising on the quality and the need of the hour. Keeping this point in mind and working upon the development of the infrastructure, we know only a well-developed infrastructure can bring back the prosperity of a region.A well-developed infrastructure includes good connectivity between the regions, transport of people, heavy as well as light goods and commodities, and so on.

With this requirements to be fulfilled there arise a need for good quality sustainable roads/pavement which can cope with the needs of the present generation and the scenario. A smart solution to this need would be Plastic Road (P.r.). P.r. signifying Plastic roads as well as meaning to strengthen public relations since the society can contribute towards this initiative, by contributing their bit by handling plastic waste effectively and not dumping them considering it to be a waste.

Plastic being common man's best friend we know it is difficult to get rid of the material. With the common man starting his day with a cup of tea which is again a plastic cup to the time he goes back to the bed with the cell-phone by his side which has a plastic case or a cover we are just surrounded by plastic because it is the cheapest as well as a durable option. So why not include them in road construction as the cheapest source of replacement to bitumen and save on the cost of construction and also provide a durable and a long-lasting solution to the problem of plastic waste disposal. Also, with the increasing demand and reliability on the road transport facility and connectivity there arise a need for good quality roads to sustain heavy traffic and very high axle loads. To satisfy this demand there is a constant search for durable and good quality roads with low maintenance cost and high performance index.

Using waste Plastic in road construction is a sustainable way to fulfill this demand and also to tackle the problem of plastic waste disposal. The inclusion of thermosplastic modifiers to virgin bitumen sample is known to improve the viscoelastic behaviour of the bitumen and also improves the overall rheological properties of the sample. This research mainly deals with providing a sustainable and a pro- environmental measure to construct a flexible pavement using thermoplastic modifiers, namely High density polyethylene (HDPE) and Low density polyethylene (LDPE) into the conventional VG 30 grade bitumen sample in different percentage so as to find the proper percentage of blend so as to provide a pavement of good quality with minimal or no maintenance cost and also to reduce the cost of construction and maintain an economy by reducing the percentage of bitumen by replacing it with plastic in shredded form. It also helps in managing a way for disposal of solid waste, particularly Plastic waste and to meet the Sustainable Development Goal (SDG). Using of waste plastic such as HDPE or LDPE in shredded form has proven to show promising results both for the environment as well as the pavement construction in term of providing better riding quality and increase in Marshal stability value and reduction in flow value as compared to conventional bitumen sample.

REFERENCES

1. Sustainable use of waste plastic modifiers to strengthen the adhesion properties of asphalt mixtures- Safeer Haidar, Imran Hafeez, Jamal, Rafi Ullah.
https://doi.org/10.1016/j.conbuildmat.2019.117496.

2. Use of plastic scrap in asphalt mixtures added by dry method as a partial substitute for bitumen D. Movilla-Quesada , A.C. Raposeiras , L.T. Silva-Klein , P. Lastra-González
, D. Castro-Fresno
https://doi.org/10.1016/j.wasman.2019.03.018

3. Experimental Study on Modified Bituminous Mix Using Waste High Density Polyethylene And Crumb Rubber Vishal Rasal, L Nokfho K, P.M.Wale, Mrunalini Kasar, Anjali Thorat, Raunak Solanki, Ishan Dharmadhikari
DOI:10.15680/IJIRSET.2018.0705101

4. Use of Plastic Waste in Bituminous Pavement. R.Manju, Sathya S, Sheema K.R.Manju et al
/International Journal of ChemTech Research, 2017,10(8): 804-811.
https://www.researchgate.net/publication/320243162

5. INVESTIGATION THE EFFECTS OF ADDING WASTE PLASTIC ON ASPHALT MIXES PERFORMANCE Ahmad M. Abu Abdo Department of Civil and Infrastructure Engineering, American University of Ras Al Khaimah, Ras Al Khaimah, United Arab Emirates. https://www.researchgate.net/publication/319312392

6. Use of waste plastic materials for road construction in Ghana Johnson Kwabena Appiaha,Victor Nana Berko-Boatenga, Trinity Ama Tagborb. http://dx.doi.org/10.1016/j.cscm.2016.11.001

7. Application of Waste Plastic Materials in Road Construction Amit Kumar Sahu1 , R. K Singh. 2 nd International Seminar On ―Utilization of Non-Conventional Energy Sources for Sustainable Development of Rural Areas ISNCESR'16.

8. Use of Plastic Waste in Bituminous Mixes of Flexible Pavements by Wet and Dry Methods: A Comparative Study Brajesh Mishra Assistant Engineer, U.P. Cane Development Department, Lucknow, India. | IJMER | ISSN: 2249–6645 | www.ijmer.com

9. Green pavements: reuse of plastic waste in asphalt mixtures Silvia Angelone , Marina Cauhape´ Casaux, Manuel Borghi, Fernando O. Martinez. DOI 10.1617/s11527-015-0602-x

10. Optimum Use of Plastic Waste to Enhance the Marshall Properties and Moisture Resistance of Hot Mix Asphalt. Assist. Prof. Dr. Hamed M. Jassim, Assist. Lect. Omar T. Mahmood , Assist. Lect. Sheelan A. Ahmed ISSN: 2231-5381 http://www.ijettjournal.org

11. Study on Marshall Stability Properties of BC Mix Used In Road Construction by Adding Waste Plastic Bottles Shiva Prasad K, Manjunath K. R, K. V R Prasad. IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE) ISSN: 2278-1684 Volume 2, Issue 2 (Sep.-Oct.Aug 2012), PP 12-23 www.iosrjournals.org

12. USE OF WASTE POLYETHYLENE IN BITUMINOUS CONCRETE MIXES. BISWANATH PRUSTY Department of civil engineering, NIT Rourkela.

13. A technique to dispose waste plastics in an ecofriendly way – Application in construction of flexible pavements R. Vasudevan, A. Ramalinga Chandra Sekar , B. Sundarakannan, R. Velkennedy DOI:10.1016/j.conbuildmat.2011.08.031

14. Effect of polyethylene on life of flexible pavements A.I. Al-Hadidy *, Tan Yi-qiu School of Transportation Science and Engineering, Harbin Institute of Technology, Harbin, Heilongjiang 150090, PR. China. DOI:10.1016/j.conbuildmat.2008.07.004

15. Behavior of Asphalt Concrete Mixtures with Reclaimed Polyethylene as Additive. V. S. Punith and A.Veeraragavan. DOI: 10.1061/ASCE0899-1561200719:6500

An overview on Smart Material for Green Infrastructure

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Abstract - "Smart Materials" will play critical role in building technology development, these materials that form a part of a sensible structural system, which has the potential to sense its environment, so smart materials can perform like living systems. And also smart materials are now days getting used altogether spheres of human life and technology. Many researches go on to utilize their potential in various engineering application which make prove useful for folk. A person's endeavour to realize the bounds of his concept of the longest, tallest and deepest has led to the worldwide go after unmatched excellence in new construction materials. The decreasing availability of suitable construction materials is putting pressure on the engineers and designers to believe methods of utilizing intelligent materials. With the arrival of advanced technology, smart materials are utilized in various engineering applications exist which incorporates Piezoelectric Materials, Magneto-rheological Materials (MR), Electro rheological materials (ER), Shape memory alloys etc. Smart materials are capable of sensing their environment and may respond accordingly.

Keywords: Smart Material, Classification, Polyvinyl chloride, Aero-gel, Application, Conclusions, References.

INTRODUCTION

Smart materials and related technologies are drawing an increasing amount of attention from researchers in related fields worldwide. Within the past decade, smart materials and structures has been one among the foremost progressive fields of research. Recently developed materials and devices are wont to address many challenges in aerospace, mechanical, bionics and medical technologies. The progress made in developing advanced materials and devices is impressive and galvanizing. Regarding to the very fact that buildings form a neighbourhood of the environment, therefore cause a bigger a part of environmental pollutions. An excellent attention has been given to the utilization of innovative smart materials to reinforce environmental sustainability, the cost-Effectiveness, and security.

New technologies and high-performance materials are being developed to satisfy these needs, offering Creative and innovative solutions to long-standing problems especially negative impact on the environment. All of them offer Benefits, whether to structural stability, the environment or to the upkeep and repair process, which can affect positively on architectural design thinking. The main goal of researching smart materials is finding the new class of materials with the tactic, considered as a multipurpose material, what required for creative architecture and construction through sustainable.

The theme of this special section is sensible actuators and applications. This is often one among the research areas of smart materials and structures that's recognized as an important aspect of smart technologies. Therefore, we have organized this special section to market the event of technology also as international Communication during this field. Within the section, current progress within the field of smart materials and structures is presented. Additionally, applications of the materials in smart structures also are included. We believe that the papers published during this special section are going to be found to supply the newest Information and can encourage more researchers to form their contribution to the present field of research.

Richard (2016):- concludes that over the last several decades, smart materials became more significant within the design of products. a sensible material is one which answer a stimulus, like a change in temperature or magnetic flux, during a particular and useful way. This might explain the slow progress of the appliance of smart structure in engineering system.

Farhat M (2018):- studied that smart materials are the materials and structures which can pass on information about their environment to an viewer or monitor are revolutionizing fields as diverse as engineering, optics, and medical technology. Now, practitioners and researchers have an authoritative source to travel to for answers about this emerging new area. Interrogation of theory, fabrication, processing, applications, and uses of those sole materials are presented here during a collection of concise entries from the world’s foremost experts within the field including scientists, educators and engineers.

Bashir Ahmed Mir (2017):- supported the fast evaluation of this paper, it’s far concluded that; clever substances aren't best useful but additionally fee effective compared to standard materials for both new and present constructions; the power destiny benefits of clever materials, structures and systems could prove awesome of their scope. Smart generation and clever materials gives promise of top of the road responses to incredibly complex issues. Clever materials offer greater preventative preservation of systems and thus higher Performance in their capabilities. The smart structure techniques in conjunction with use of smart substances revolutionize in tracking the security and serviceability of engineering shape, structural health tracking of important engineering structures like bridges, homes, pavements etc. consequently, expertise the conduct of any clever material is that the remaining goal of studies within the area smart era.

Susmita Kamila (2013):- concludes that the existing age is taken into consideration to be the smart substances era. In advance, smart cloth changed into described as the fabric, which responds to its environments in a well timed way. But, the definition of clever materials has been improved to the materials that get hold of, transmit, or manner a stimulus and reply with the aid of producing a useful effect which could consist of a signal that the substances are performing upon it. This take a look at focuses on the advent of clever materials and their classifications.

CLASSIFICATION OF SMART MATERIALS

Smart materials are the products of advent of latest Emerging science and technology. The arrivals of smart Materials has revolutionized their use in a lot of Infrastructural systems and also are learning at an unprecedented pace. Smart materials are often classified into the subsequent categories (Fig.), which may be used either as Sensors or Actuators or both. A number of these smart materials are briefly outlined as below:

• Poly vinyl chloride :-

PVC is replacing conventional building materials like wood, metal, concrete and clay in many applications. Versatility, cost effectiveness and a superb record of use mean it's the foremost important polymer for the development sector, which accounted for 60 per cent of European PVC production in 2006. PVC , is one among the foremost popular plastics utilized in building and construction. it's utilized in beverage and waste water pipes, window frames, flooring and roofing foils, wall coverings, cables and lots of other applications because it provides a contemporary alternative to traditional materials like wood, metal, rubber and glass.

Advantages :-

• It‘s lightweight and powerful
• It’s easy to put in
• It’s durable
• Safe material

• Aerogel :-

Aerogel may be a simulated porous extremely light material derived from a gel, during which the liquid component for the gel has been exchanged with a gas without significant collapse of the gel structure. The result's a solid with especially uniqueness and very low thermal conductivity. Nicknames comprise frozen smoke, solid smoke, solid air, solid cloud, blue smoke due to its clear nature and therefore the way light scatters within the material. Silica aerogels feel like fragile enlarged polystyrene to the touch, while some polymer-based aerogels feel like rigid foams. Aerogels are often made up of a roll out of chemical compounds.

Advantages :-

• Aerogel is made of more than 90% of air, having extremely low weight.
• Excellent thermal conductivity.
• Aerogels are very light, as they are about 95% porous.

ISBN: 978-93-90214-19-8

APPLICATION

Smart materials find an honest of applications because of their varied response to external stimuli. The various Areas of application are often in our day to day life, Aerospace, engineering applications and Mechatronics to call a couple. The scope of application of Smart material includes solving engineering problems with unfeasible efficiency and provides a chance.

For creation of latest products that generate revenue. Important feature associated with with smart materials and Structures is that they encompass all fields of science and Engineering. As far because the technical applications of smart Materials cares, it involves composite materials.

• Civil structure
• Energy saving
• Aerospace
• Reducing waste
• Sports equipment
• Robotics
• Smart fabric
• Medical device

Smart materials and systems have a good range of applications. Investment in research and development is driven by factors like legislation, reducing waste and demand for higher quality of life. Structures like buildings, bridges, pipelines, ships and aircraft must be strongly designed and frequently inspected to stop 'wear and tear' damage from causing disastrous failures. Inspection is dear and time consuming, while designing to stop damage can compromise performance. With some modern materials, damages are often internally serious but leave little or no surface evidence.

CONCLUSIONS

Supported the brief review of this paper, it's concluded that:-

1. Smart materials aren't only useful but also cost Effective as compared to standard materials for both New and existing constructions.
2. The potential future advantage of smart materials, Structures and systems would prove amazing in their Scope.
3. Smart technology and smart materials promises to have Optimum responses to highly complex problems.
4. Smart materials provide increased preventative Maintenance of systems and thus better performance of their functions.
5. The smart structure techniques in conjunction with use of smart materials revolutionize in monitoring the security and serviceability of engineering structure, Structural Health monitoring of important engineering structures Like Bridges, Buildings, and Pavements etc. The ultimate objective of research within the field smart technology.

REFERENCE

[1] Addington D. M. and Daniel L. S., Smart Materials and New Technologies. Elsevier, 2005, pp. 255.

[2] Akhras G., Smart Structures and their Applications in Civil Engineering. Civil Engineering Report, CE97-2, 1997, RMC, Kingston, Ontario, Canada.

[3] Bank, H. T., Smith, R. C. and Wang, Y., Smart Material Structures, Modelling, Estimating and Control. John Wiley And Sons, 1996.

[4] Culshaw, B., Smart Structures and Materials. Artech House Inc, 1996.

[5] Singh H. and Singh R., Smart Materials: New Trend in Structural Engineering. International Journal of Advance Research and Innovation, 3 (4), 2015, pp. 661-664.

[6] Ravikumar C. S. and Thandavamoorthy T. S., Application of FRP for strengthening and retrofitting of civil engineering Structures. International Journal of Civil, Structural, Environmental and Infrastructure Engineering, Research and Development, 4 (1), 2014, pp. 49-60.

[7] Brei, D., Smart Structures: Sensing Technologies for Structural Health Monitoring. SAE Technical Paper Series, 981508. 1998.

[8] Kamila S., Introduction, classification and applications of Smart materials: an overview. American Journal of Applied Sciences 10 (8), 2013, pp. 876-880.

[9] Cai C. S., Wenjie Wu, Suren Chen and Voyiadjis G., Applications of Smart Materials in Structural Engineering. LTRC Project No. 02-4TIRE, Department of Civil Engineering, Louisiana State University, Baton Rouge,Louisiana 70803, 2003, pp. 1-71.

[10] Krishna J. G. and Thirumal J. R., Application of Smart Materials in Smart Structures. International

Journal of Innovative Research in Science, Engineering and Technology 4 (7), 2015, pp. 5018-5023.

[11] Akhras, G., Advanced Composites for Smart Structures. Proceedings, ICCM-12, 12th International Conference on Composite Materials, Paris, July 5-9, 1999.

[12] Joan R. Casas and Paulo J. S. Cruz, Fiber Optic Sensors for Bridge Monitoring Journal of Bridge Engineering, 8(6), 2003, 0702(2003)8:6(362), © American Society of Civil Engineers.

[13] Waandres, J. W., Piezoelectric Ceramic: Properties and Applications. Philips Components Marketing Communications, 1st Edition, 1991.

[14] Lee M., Chen C. Y., Wang S., Cha S. N., Park, Y. J., Kim J. M., Chou L.-J. and Wang Z. L.(2012). A Hybrid Piezoelectric Structure for Wearable Nanogenerators, Adv. Mater., 24 (13), pp. 1759-1764.

[15] Duerig T. W, Melton K. N, Stoeckel D., Wayman C. M.,Engineering aspects of shape memory alloys. Butterwort Heinemann Ltd: London, 1990.

[16] Caia G. F., Zhoua D., Xionga Q. Q., Zhanga J. H., Wanga X. L., Gua C. D. and Tua J. P., Efficient electrochromic materials Based on TiO2@WO3core/shell nanorod arrays. Journal of Solar Energy Materials and Solar Cells. Vol. 117, 2013, pp. 231-238.

An Overview of Application and Performance of Bacterial Soil Stabilization

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Abstract - Microbial induced calcium precipitation is one of the important developing techniques in ground improvement. This technique is mainly based on Bio mineralization, which is the process of producing minerals (calcium carbonate) by living organisms called microbes. This technique is widely used in various fields such as Biotechnology, Geo technology and also in paleo biology. Apart from the above applications, it is also used to remove the heavy metals, radio nucleotide, and atmospheric carbon dioxide sequestration. In this paper, the approaches of various researchers on this technology applied for different types of soil such as clayey, silty soil, sandy soil and analyzed their optimum conditions to achieve their maximum shear strength. This manuscript also discusses various influencing factors of microbial induced calcite precipitation like Calcium concentration, dissolved matters of inorganic carbon concentration, pH of bacterial solution, and nucleation sites availability predominantly. It also deals with the importance of the processing of bacteria at the optimum condition to adopt sustainable soil stabilization. The various precipitations of polymorphs forms were effectively discussed.

Keywords: bio mineralization, bio geo Stabilization, microbial induced carbonate precipitation, pH, sporosarcina pasteurii.

INTRODUCTION

Bio soil stabilization is one of the rapidly emerging ground improvement techniques in geotechnical engineering. Biologically induced minerals help to improve the index and engineering properties of the soil. This technique would increase the effective stress of the soil stratum and also works in a sustainable manner. In conventional techniques, chemically induced cementation might increase soil stability but it has led to hazardous environmental pollution which spoils air, soil and underground water. The basic merits of traditional methods are less investment and maintenance costs. Even though the process of biologically induced calcite precipitation is slow and complex, it is nontoxic for nature and human beings. Naturally induced calcium carbonate by microbes has two different approaches namely, Bio clogging; this fills the voids with microbial metabolism and Bio cementation which binds the soil particle with the help of microbial induced minerals. "Cheng et al. (2014) has proposed the method of bio cementation in sand using microbial induced calcium precipitation (MICP) saline soil". The authors conducted a series of tests by varying different parameters like urease utility crystal content and permeability in a constant head permeability test, UCC, and microscopy analysis method. The test results were shown that the compressive strength of the sample treated with seawater was higher than that of a high concentration of cementation solution.

2. Factors involving in Soil Stabilization

2.1. Bio Geo Chemical Reactions

The natural chemical reactions take place between the microbes and soil existing mineralogy, and it produces the end product which leads to the improvement in permeability, porosity, shear strength and stability. "Bio Geo chemical Reaction has been studied through microbial induced calcium carbonate (Dejong et al., 2013; Whiffin et al., 2007; Ng et al., 2012) and enzymatically induced carbonate (Sungsik et al., 2014; Paulo et al., 2016) by various authors". In the current paper, studies on microbial induced calcium carbonate, factors influencing the process, implementation difficulties and approaches to different types of soil are reviewed.

“As researchers made an attempt on sand through bio mediated calcite precipitation (Dejong et al., 2010)”. He has managed the reaction between microbes and soil minerals and controlled the metabolic activities to improve the properties of the soil such as stiffness and their strength. He has also reviewed the role of the biological process with respect to the timing rate and distribution of chemical after the reaction. He discussed the failure mechanism of calcite, induced by the bacterial reaction in different levels and due to shear and compression and tension leading in the construction site. The author has been analyzed the resistivity, compression site. The author has also been analyzed the resistivity, compression waves and shear waves of biomedical samples and also reviewed the significant improvement in stiffness, permeability, and shear strength. “DeJong et al. (2010) has depicted the process of Bio Geo Chemical Reaction (Fig.1).”

“Navedeep et al. (2018) has reviewed the microbially induced calcium carbonate precipitation produced by ureolytic bacteria”. The biometric carbonate produced by bacteria is used to improve the durability of building, remediation of environment and reservation of atmospheric CO2 filler material in rubber and plastics. Author also discusses the synthesis of minerals using prokaryotic in two different methods. One is biologically controlled and another one is biologically induced mineralization Calcium precipitation by the microbes are relatively managed by four different factors they are:

• Calcium concentration
• The dissolved inorganic carbon concentration
• PH
• The availability of nucleation site

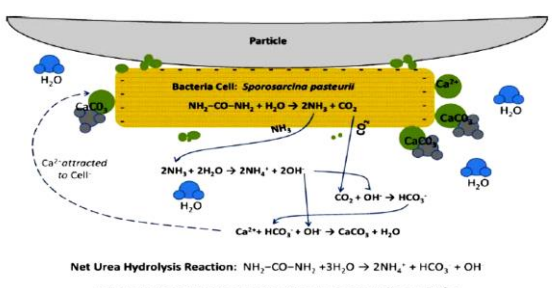

Fig. 1. Bio-mediated carbonate precipitation using ureolysis (Dejong 2010)

Calcium carbonate precipitation should have enough calcium and carbonate ions, so that the ion activity product exceeds the solubility constant (Ω). The author has also reviewed three different anhydrous polymorphs of calcium carbonates. They are calcite, aragonite, and vaterite. The author concluded that MICP is usually slow and complex when it is used for dangerous area. “The detailed review possessing of Bio deposition and Bio cementation was reviewed by (Muynck et al., 2010)”. In bio deposition, the author described the application of carcinogenic bacteria in laboratory-controlled conditions and also insect treatment. Bio deposition process on cementitious material with the calcium acetate was achieved the significant results. Bio cementation process has effective increase of 28 days compression strength by 25 percentages. The authors also discussed the cost evaluation of Bio deposition and Bio cementation process. They also had a review of alternative microorganisms and metabolic activities in the different methodologies.

“As highlighted by (Shiping et al., 2015), the bacterial strain was isolated from marine sediments and purified DNA was extracted”. The authors tested the bacteria for urease activity in urea against the media and quantified the calcium carbonate precipitation. They also analyzed the mineralogy using scanning electron microscope. During the analysis, they found that B. Lentus grew faster and precipitated more CaCO3 than the B. Diminuta and S. Soli. It was concluded that B. Lentus pH condition of increased from 8.3 to 9.4 and Ammonium ion concentration reaches 608 mm, has a maximum growth and their morphological crystals were cubic and rhombic in structures.

2.2 Microbially induced calcium carbonate (MICP)

Inadequate land area in urban region and due to a rise in population during the recent decades has led to stabilize the soil stratum and to achieve the necessary shear strength to withstand the structures. In this regard, many researchers have studied about the effects of microbial induced calcium carbonate in sustainable manner. A list of different organisms and their application test details were described in (Table 1). “In order to increase the shear parameters of soil microbial stabilization has been conducted by researchers (Cheshomi et al., 2018; Salwa et al., 2011; Chi et al., 2017) and their results are revealed”. The main activities of the microbes to

ISBN: 978-93-90214-19-8

produce carbonate crystals in the soil voids may be due to:

- Production of microbial metabolism
- Nucleation site of carbonate on cell wall
- Involving extracellular macromolecules

"Carbonate crystals were found on the external surface of the bacteria by successive stratification (Navdeep, 2013; Pakbaz and Alipour, 2012; Cunningham et al., 2018)". The equations which below describes the calcite precipitation by bacteria as shown in Eqs (1-3).

$$CaCl_2 \rightarrow 2Cl^- + Ca^{2+} \quad (1)$$

$$CO(NH_2)_2 \rightarrow CO_3^{2+} + NH_4^+ \quad (2)$$

$$Ca^{2+} + CO_3^{2-} \rightarrow CaCO_3 \quad (3)$$

Table 1. Review of different organism and their application test details

S.No	*Soil for Analysis*	*Bacteria considered*	*Culture medium used*	*Parameter Analyzed through*	*Results*	*Author and year*
1.	Silty sand – 70% Kaolinite – 15% Bentonite – 15%	Bacillus Sphaericus	Na bicarbonate-2.12 Nutrient broth-3 NH_4Cl-10 Yeast extract-20,Urea-10	Direct shear test XRD	UCS, Friction parameters	(Rahim et al., 2017)
2.	Pure silica Sand	Bacillus Sphaericus	Yeast extract-20g/l Ammonium sulfate - 0.17M 0.1mm Ni^{2+}	Permeability UCC Calcium carbonate content	Ph vs UCS Ph vs $CaCo_s$ No of flushes vs UCS	(Cheng et al., 2014)
3.	Sand (tween 80)	Sporosarcina Pasteurii	Yeast extract-20g/l 10g-$NH_4)_2So_4$IIL Of 1.3M	Strength Stiffness Permeability SEM	Pore volume relative OD calcite content	(Dawoud et al., 2014)
4.	1, Fine-Grained Sand 2, Poorly Graded Sand	bacillus sphaericus	Na bicarbonate-2.12 Nutrient broth-3 NH_4Cl-10 Yeast extract-20 Urea-10	Direct shear test SEM XRD	Shear strength	(Hataf and Jamali, 2018)
5.	Sand (karoon river)	Sporosarcina pasteurii	(tryptic soy agar) TS, medium 2% urea 180 rpm 1.5-1.6 at 6.00nm	Direct shear test SEM	Vertical stress horizontal displacement	(Pakbaz and Alipour, 2012)
6.	Quartz sand	Sporosarcina Pasteurii	Yeast extract-20g/l 10g $NH_4)_2So_4$	Direct shear test XRD	Calcium content, stress and density	(Cunningham et al., 2018)
7.	Liquefiable soil (snake river)	Sporosarcina Pasteurii	Molasses cH_3cooNa	XRD Insitu test CPT	Calcite mass vs depth	(Malcolm et al., 2011)
8.	Coastal deposits	Sporosarcina Pasteurii	Ammonium-yeast Extract medium-20g/l – 10g/l-$NH_4)_2So_4$	UCC Soil column test	Cohesion and friction	(Montoya et al., 2013
9.	Aeolian sand Pure sand Mixture combo (6)	Sporosarcina Pasteurii	20g/l – yeast extract 200rpm for 48m centrifuged 400g for 20min	Triaxial shear(UU) UCC	UCS, shear parameter, calcium concentration	(Chi et al., 2017)
10.	Sand particles	Paenibacillus	Sucrose culture 10g-sucrose 3g-disodium hydrogen phosphate Ph=7.0	Hardness compressive strength porosity, calcite content micro structure wind erosion control resistance	Increase in hardness	(Qi et al., 2017)
11.	Ottawa silica sand	Sporosarcina Pasteurii	Ammonium-yeast extract medium	UCC, Reaction time stress-strain behavior urease concentration	Increase in Bacterial concentration more than urease	(Qian et al., 2010)

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12.	Tropical residual sand	Bacillus megaterium	5g/l peptone, $NaCl_2$ 2g/l yeast extract 1g/l beef extract	Bacterial concentration low-pressure duration cementation reagent	UCS, content	Calcite	(Ng et al., 2009)

2.3. Enzymatically induced calcium carbonate precipitation

"Urease activity in the process of calcium carbonate precipitation between the soil grains using power extracted from the jack bean plant (Whiffin et al., 2007; Chou et al., 2011; Paulo et al., 2016)". "Many researchers have used the extracts taken from the plant (jack bean) as a urease catalyst which could induce the precipitation of carbonate (Hideaki et al., 2012)". Using the urease enzyme from the plant as a bioreaction catalyst to enhance the UCS values from 400 to 1600 kPa. "Chang et al. (2018) were tried using biopolymers (Thermo geleting) including agar gum, gellan gum and Xantham gum to strengthening soil at saturated conditions". They have proposed to improve the shear strength parameter of the sand lay mixture using Thermo gelatin biopolymer like agar gum, gellan gum, xanthan gum. The authors conducted the vane shear test and direct shear strength in the laboratory for finding out the different percentages of sand-clay mixture, xanthan gum, and soil densities. The result shows that friction parameters are significantly improved for clay and sand-clay mixtures. The ratio of the mass of Gellan gum to clay was a predominant factor to improve the strength of the soil and it was optimized at 4 percentages for kaolinite rich foils.

"Sungsik et al. (2014) has involved in the improvement of shear strength in sand taken from the Nakdong River, Korea and made an attempt for microbial induced calcite precipitation in soil". The extraction of the jack bean plant acted as a catalyst and it was added to the urea solution to improve the qualification of calcite. The urea solution also assists with calcium chloride, calcium hydrochloride, and calcium nitrate. An unconfined compression test value of treated sand with urea solution was increased compared to the untreated one. Treated sand with plant extract strength was also compared to sand without plant extract. "Paulo et al. (2016) analyzed the effect of different soil types on enzymatic calcium precipitation". The author has taken Peat soil, sand, silt, organic soil is respectively denoted as PS, S, M, OS and stabilized with the enzyme. The strength and stiffness of the soil were tested through an unconfined compression test - UCC and Scanning electron microscope - SEM analysis. They conclude this MICP metal is effective in coarser and well-grained soil. For coarser, the above method was not effective because thin layer CaCO3 could not sufficient to bond the larger particle. They examined that the low pH value of organic soil does not have improvement by the bio stabilization method. "Nemati et al. (2003) has made an attempt to produce the enzymatic formation of CaCO3". They applied in the consolidated porous media and Berea sandstone cones to observe the increase in enzyme and reactants concentration leads to enhance rate and quantity of CaCO3. They conducted the experiment by infecting the reaction mixture to reduce the permeability up to 98 percentage. The author concluded that the injection method is highly used to reduce the permeability in an oil reservoir, consolidation of sand and capture of radionuclides and trace elements contaminate in groundwater system.

"Hideaki et al. (2012) has conducted the experiment work on sandy soil and stabilized through enzymatically induced carbonate precipitation". It was concluded that increases in the rate and magnitude of CaCO3 precipitation. The authors examined the sample which has been treated with bio catalyzes for test-tube experiment, and analyzed the pH and calcium concentration for a different time period. In the unconfined compression UCC test, a sample was prepared under the confining pressure of 50 kPa and cured for 24 hours. The unconfined compressive strength of the sample was increased up to 1600 kPa than an untreated sample, UCS values of 900 kPa. They also observed that hydraulic conductivity was decreased with respect to time and the number of injections. They have developed the numerical analysis and compared it with experimentation conducted laboratory results were shown satisfactory.

2.4. Factors influencing MICP

"Researchers broadly analyzed MICP, based on the various factors affecting the microbial stabilization

ISBN: 978-93-90214-19-8

(Ng et al., 2014)". "Mainly the bio stabilization process has been regularized by four significant parts: concentration of calcium ions, the concentration of dissolved inorganic carbon, pH, availability of nucleation site, temperature, Number of spraying, Effect of reaction time, the effect of curing conditions, effect of soil types and urease conditions (Nemati et al., 2012; Gebrehiwet et al., 2000; Dejong et al., 2006)". Based on the control condition of microbial stabilization, the efficiency of production of calcium carbonate has been determined.

"Ravi et al. (2011) conducted the experiment on factors influencing the bioaugmentation and biostimulation strategies of MICP". They were developed the co-culture of uncontrolled culture through ureolytic bacterium sporosarcina pasteurii. It was introduced into the medium non-ureolytic condition of bacterium Bacillus subtilis with the complement of additional carbonate sources like molasses. Effective bio stimulation is achieved by indigenous ureolytic bacteria 200mM urea. The author concluded that the enrichment of ureolytic bacteria soil with low urea concentration will facilitate effective post enrichment and cementation recovery treatment. Effect of bacterial concentration plays a significant role with respect to optical density. As OD600 increases, UCS values also increases. "Shear strength values increases with increase in cementation media concentration (Lin et al., 2014)".

"Effect of bacterial fixing time shows a great deal of efficiency in initial days and it becomes slower in subsequent increase in days (Ng et al., 2014)". Granulometry of soil shows the ability of production of calcite crystal in voids. Grain size is more, calcite production also more and vice versa. "The optimum pH used for the urease activity was studied by (Stocks et al., 1999; Dejong et al., 2011) and found that it lies in the range of 7.5 to 8.0".

"The urease rate was higher at the temperature of 30 degrees Celsius compared to 20 degrees Celsius (Cheng et al., 2013)". "Curing conditions were also studied by the researchers, to find out the effect of various temperature samples and analyzed that air-dried at room temperature (20°C) has achieved considerable UCS values than that of 30°C and -18°C (Qian et al., 2010)". Various influencing parameters and their optimum condition has been discussed (Table 2).

Table 2. Influencing parameters of MICP and their optimum conditions.

S.No	*Property*	*Optimum conditions*
1.	OD_{600}	0.3-0.6
2.	Concentration of cementation media	0.25-0.5
3.	Reaction Time	3-5 days
4.	pH	7.5 to 8 days
5.	Temperature up to 30˚C	30 °C
6.	Fixation and distribution of bacteria	Increase in high salinity solution

"Qian et al. (2010) studied the various factors influencing the engineering properties of bio treated soil". As researchers conducted the experiment with sporosarcina pasteurii in sandy soil from Ottawa and it has 99.7 percentage of quartz. He has analyzed the unconfined compression strength of treated soil. He prepared the fully flexible contact mould for sample preparation using geotextile. All soil samples were submerged into the cementation medium for using a period of 7 days. The author has tested the samples for the effect of calcium precipitation with respect to stress-strain behavior, bacteria and cementation media concentration, reaction time curing condition, sand type and increase concentration. The author concluded that cementation media concentration increases with UCS values and also suggested that $CaCo_3$ content and UCS of bacteria treated sample is always more than increase treated samples.

"Qabany et al. (2011) has discussed the factors influencing the efficiency of Microbial Induced Calcite Precipitation (MICP)". They studied about the optimal use and efficiency control of Sporosarcina Pasteurii of various factors like the concentration of chemicals, retention time, and effective input rates on chemical efficiency, and also measured the chemical efficiency by comparing the calcium carbonate precipitation with the number of injections of chemical reactants to samples. The prime time mandatory for precipitation for a definite range of bacterial optical density in a porous medium was determined. The author concluded that reaction efficiency was high, and the precipitation rate was not affected by the infected concentration at higher input rates. The efficiency decreases because urea hydrolysis was slower than the input rate. At lower input rates, urea hydrolysis and CaCo3 precipitation started decreasing after a nutrient was supplied for the bacterial growth. After the (SEM) scanning electron microscope study was carried out by the authors for the various samples at numerous concentrations showed that, for the same amount of precipitation, and use of lower chemical concentration in injection resulted in better distribution of calcite precipitation.

"Ng et al. (2009) analyzed the typical tropical residual soil for increasing the engineering characteristics of soil by treating the soil with Bacillus megaterium". The authors have discussed the concentration of bacteria and cementation reagent factors. The prepared samples were influenced by 16.6 percentage of water content and sensitivity of 1519 kg/m3. The mould was connected to pressure vessel for maintaining the uniform pressure in the moulds. The authors studied the variable of concentration of bacteria and regent used, also about duration and flour pressure unconfined compressive strength test conducted under the controlled condition for different samples, and analyzed that UCS values were increased 69 percentages and hydraulic conductivity was decreased by 90 percentages. The following points are highlighted in the topic of factors influencing microbial induced calcium carbonate precipitation:

•Flow pressure increase, then UCS values decrease.
•Flow pressure increase, then calcite increase then decreases.
•Flow pressure increase, hydraulic conduct decrease then increases.
•Duration increase, then calcite content increases.
• Duration increase, then UCS values increases.
•Bacteria concentration increase, then calcite content increases.
•Bacteria concentration increase, then UCS values increases.
• Time increase, then NH4 increases.
• Time increase then PH increases.

2.5. Applications of MICP at different areas

"From the literature studies, it has been reported that microbial stabilization applied for various fields to treat the wastewater, carbon dioxide sequestration, Biological mortar, Remediation of cracks in concrete, bacterial concrete, removal of heavy metals and radionuclide and filter for rubber plastics and ink (Navdeep et al., 2013; Muynck et al., 2010)". Bacterial mortar would be optimized by the three major components of limestone powder, nutrient, and Bacterial paste. "Mostly sculptures have been treated through this bacterial mortar and researchers (Lee et al., 2013) review shown satisfactory results".

"Concrete has been assorted with sporosarcina pasteurii shows that increases in the compressive strength of mortar cubes (Ramachandran et al., 2001)". He also studied the effect of biomass in the case of dead cells results in a decrease in strength due to lack of oxygen. Crack remediation has also been done using microbes (Bacillus Pasteurii) with the optimized pH range of 9 (alkalinity). Apart from the geotechnical and concrete application, it has been also used in Environmental Engineering for the removal of heavy metals, radionuclide and arsenic, when it is mixed with groundwater. "Bioremediation has been carried out to remove the foreign matters from the groundwater through the sporosarcina for providing the qualitative solution (Gebrehiwet et al, 2012; Achal et al., 2011)". Carbon dioxide sequestration has been studied by (Shaffer et al., 2010; Liu, 2005; Tam et al., 2007) at various field scale to absorb, dissolve and convert CO2 into other forms of calcite, Dolomite and Magnetite. Bio remediation for different field applications is shown in Table 3. "Achal et al. (2011) reviewed on living microorganism which produced the calcium mineral for improving the strength, stability, and durability of the various building materials".

Table 3. Bio remediation field applications

S.no	***Species name***	***Application field***	***Author and year***
1.	Sporasarcina ginsengisoli	Arsenic contaminated water	Achal et al., (2012)
2.	S.pasteurii	Removal of calcium ions	Okwadha and li, (2010)

ISBN: 978-93-90214-19-8

3.	Bacillus psedufermus and cohnii	Self-healing concrete	Jonkers et al., (2008)
4.	Bacillus cereus	Biological mortar	Maheswaran et al., (2014)
5.	S.pasteurii	Remediation of cracks in concrete	Zhong and Islam (2017)
6.	S.pasteurii	Bacterial concrete	Ramachandran et al., (2001)

A compressive strength was improved by 25% then it was missed with Shewanella sp through bio cementation. Bio deposition method used on cementitious specimens reduces the permeability of water and gas into a specimen. It was achieved by the material subject to immersion, pounding or spraying method. Bioremediation methods are used to prolong the life of monuments, or any environmental effects or any accidental damages. The authors conclude that various properties like strength, permeability, of chloride ion and water and reinforcement carrier has been improved by the MICP method.

"Dawoud et al. (2014) has made an attempt to increase the efficiency of uniform distribution of calcite". Batch test was conducted to determine the effect of surfactants on urease activity, and column test was used to analyze the efficiency of bacterial distribution. Author prepared the treatment media of 20g yeast extract of 10g of (NH4)2So4 per 1Litre of 0.13 Morality with pH 9.0 under the sterilized condition, the media was moved to the Erlenmeyer flasks with an aeration ratio of 1:5 and added the select surfactants with concentration 1 and 0.1 percentage for Tween & 0, 10 and 100 mg/c for sodium Dodecyl. The effect of SDS has been shown the exempted effect on the microorganism & urease activity whereas Tween has facilitating bacterial delivery. The author concludes that treatment becomes more effective for large scale and bacterial distribution. It can be applied to deeper infection. "Hataf and Jamali, (2018) investigated on the effect of fine-grained percentage in soil". The soil properties were tested for the sample treated with microbial calcite precipitation, two types of samples were selected by authors to evaluate the effect of fine-grain percentage on soil shear strength. A poorly graded sand and low plasticity clay were treated with bacillus sphaericus bacteria for calcium carbonate production with high acidity. The results obtained by the test were compared with untreated soil and biologically treated characteristics, concluded that the shear strength of MICP treated soil was increased. when fine-grained percentage increases, shear strength was decreases. For effective calcium precipitation, the optimum fine grain or clay content percentage should not be more than 20.

"Malcolm et al. (2012) made an attempt to increase the quantity of microbial concentration in liquefiable soil". They identified the impacts of carbon concentration in ureolytic microbial growth and effects of calcium carbonate secretion. Soil column test was conducted to find enrichment of ureolytic microorganism in lab and field as well. From the cone penetration test data, there was significant interest in tip resistance for low levels as 1.8 to 2.4% in order to enrich calcite precipitation, the medium contains 0.5 percentage or greater of molasses, 170mm acetate, 0.1gram per liter yeast extract, 250mm CaCl2, 12.5mm NH4Cl and 333mm urea were added in the soil medium for improving the urea hydrolyzing in the presence of CaCl2. The author concludes that enriching the indigenous bacteria is more efficient than introducing exogenous bacteria. "Montoya et al. (2013) have recommended that unsaturated soil strength was improved by intermittent surface treatment to mitigate the damage in coastal infrastructure, highways, pipeline, and other utilities". The authors have investigated the sandy soil in a lab with a relative density of 40 percentage, they are prepared soil column by applying urea hydrolyzing bacteria called sporosarcina pasteurii. Unconfined compression test is conducted for the top and bottom commented soil sample and denotes as 5 kPa and the angle of failure plain was 63 degrees. They were concluded that coastal sand deposit was improved by treating the soil with bacterial metabolic activity.

EVALUATION OF EXISTING METHODS

3.1. MICP treatment in different types of soil

"Microbial soil stabilization has been carried out in different types of soil such as sand, clay, coastal soil, liquefied soil and organic soil by various researchers like (Okwadha and Li, 2010 ; Cheshomi et al., 2018; Chi et al., 2017)". "Bio clogging and bio cementation are the two different approaches dealt with Bio geo stabilization process (Dejong et al., 2013; Ng et al., 2012)”. “Aeolian sand has been treated with sporosarcina pasteurii to improve the geo mechanical properties to mitigate the wind erosion in desert region (Chi et al., 2017)”. The authors have planned to study the effect of sandy soil treated with Bacillus pasteurii microbes. “Researchers has achieved an 86% increment in shear parameters such as cohesion and internal friction within a span of 15 days (Pakbaz and Farzi, 2015)”. Cohesive soil has been treated with microbes by different methods like Injection, Premixing and Diffusion techniques. It has been analyzed for unconfined compression strength. “Cheng et al. (2012) has concluded that the diffusion method has shown a 200% increment in UCS Values” . “Qabany et al. (2011) has referred Scanning Electron Microscope image for bacterial treated soil sample and it is shown in (Fig. 2)”.

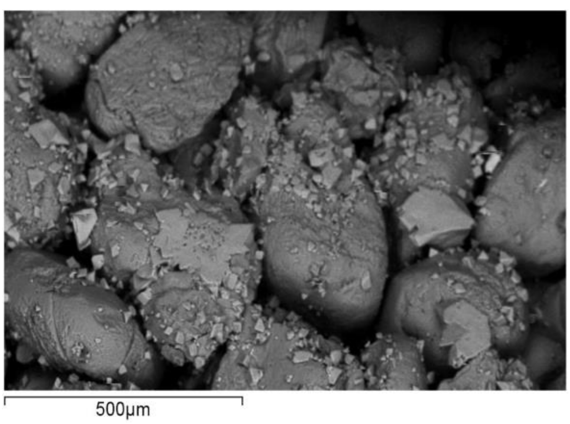

Fig. 2. SEM image for soil sample, Qabany et al., (2011)

“Qian et al. (2010) proposed eco-friendly technology called biomineralization to improve the shear strength of sandy soil”. The authors have studied the bacteria of three different varieties and analyze the activity for precipitation of carbonate. Each bacterium is developed in the different medium and pH conditions. In order to increase the usual activity of bacteria, purification is done to bacillus S3 bacteria through slab culturing. The authors have analyzed bacteria based on high activity experimental work, which has been carried out for consolidating the soil sample by applying the high activity of selected micro bacteria. Two samples are selected at different permeability rates for the analysis, and it was found that the compressive strength of the soil sample was found more for the loss of consumed bacteria. They also analyzed calcium carbonate content through thermogravimetry quantitative analysis.

“Chi et al. (2017) et al has analyzed the Aeolian sand properties by treating with bioremediation method”. The authors mix aeolian sand with the standard sand in a different ratio, and conducted the triaxial shear and the unconfined compression test. Sporosarcina pasteurii is acted as a catalyst of concentration 1.7-6.8 * 10^-7 cell/ml. The authors conclude that microbial induced calcium precipitation treated Aeolian sand can be applied for biocrust to mitigate wind erosion. “Cheng et al. (2014) have investigated the calcium precipitate microbes for improving the strength and stiffness of clay soil”. The authors have chosen three different types of methods for diffusing the bacteria into the clayey soil (Clayey sand) which has 20 percent of clay content. They adopted MICP treatment for sand column less than 5 percentage clay content and exponential relations between UCC (Unconfined compressive strength) and calcium secreted by the microbes. The premising of bacteria cells in a sand column and subsequent infection of cementation under the pressure of 100 kPa, it is showing the 150 percentage of increase in the (UCS) Unconfined compression strength values. The diffusion method is used to treat the clayey soil with 20 percentage of clay content; it is shown a considerable increase of 200 percentages in UCS values. Authors concluded that bio-cementation of a clayey soil is challenged and it requires further investigation on ureolytic bacteria for large field scale.

“Whiffin et al. (2007) were investigated on 5m sand column, which is treated with ureolytic bacteria for instinct conditions”. Microbes are injected for entire 5m length @ low pressure without clogging and their reaction are monitored the flow rate of infection is maintained as 7m/day, and the hydraulic gradient is less than one, then their 5m the column is tested for mechanical properties like strength and stiffness. There is a notable change in the reduction of pore volume, an increase in the amount of CaCO3 solids precipitated; decrease in urea concentration the average permeability over the treated 5m column is improved from 2x10-5 to 9x10-5 m/s. The author

 ISBN: 978-93-90214-19-8

also notices that at the infection point of bacteria is associated with dogging. Due to clogging, permeability is reduced and it is an undeserved factor. Authors also determine the urease activity by two different methods, like the dilution method and rate of ammonium production method, and both were correlated.

"In order to find out the effect to desaturation in liquefaction soil, (He et al., 2016) has made an attempt to produce the nitrogen gas through microbial denitrification process". They found that the gas phase is stable under hydrostatic conditions and unstable underwater flow conditions. "Han et al. (2016) has made a study on liquefiable sand to raise the strength with the help of microorganism Bacillus pasteurii". He observes that solidification after multiple treatments is more effective than the less treatment in 2 days. Quartz sand has been treated by the microbial method using sporosarcina pasteurii to analyze the effect of soil density, injection time and the impact of a number of injection days. "Cheshomi et al. (2018) has found that shear strength improves at low density effectively when compare with high-density specimens". "Cheng et al. (2014) have also investigated on the effectiveness of bio-cementation of silica sand in different environments and physical aspects like soil density, temperature, and pH". Laboratory tests are conducted to determine the soil permeability and calcium content for soil treated by the MICP. The results are indicated that for initial density, the process of bio-cementation is more effective. Similarly, for high temperature (500 degrees celcius), it is not much effective than room temperature, and pH for 2 extreme conditions (acidic and alkaline) was adverse to develop the strength. MICP samples retained the permeability to maintain a drainage condition, allows dissipation of excess pore water pressure at a higher rate. An author was also made an attempt MICP treatment on coastal sand and has a result of reasonable strength and effective crystal formation. "Hataf and Jamali, (2018) investigated on the effect of fine-grained percentage in soil". The soil properties are tested for sample treated with microbial calcite precipitation, two types of the sample were selected by the author to evaluate the effect of fine-grain percentage on soil shear strength. A poorly graded sand and low plasticity clay are treated with bacillus sphaericus bacteria for calcium carbonate production with high acidity. The results obtained by the test are compared with untreated soil and biologically treated characteristics, and it is that concluded the shear strength of MICP treated soil is increased. Fine-grain percentage increases, when the shear strength decreases up to soil. The optimum fine grain or clay content percentage should not be more than 20 for effective calcium precipitation.

"Cheshomi et al. (2018) were investigated loose quartz sand with x-ray diffraction and scanning electron microscopy to analyze the cement formation after it has been treated with microbes". The shear strength has been increased in the quartz loose sand after the microbial injection as 3.9kg/cm2 whereas before treatment it has been 0.63 kg/cm2. The authors also analyze that the effect of injection time at two-stage injections per day is comparatively greater than the one and three-stage injection time. While extending the injecting time, from 1 to 5 days shear parameters also increase from 2.07 to 4.54 kg/cm2. The shear strength also has a significant increase by increasing the bacterial treatment period. "He et al. (2016) were proposed a new method to mitigate the soil liquefaction by generating nitrogen gas through microbes". They discuss desaturation in the soil through the denitrification approach. The authors have conducted a shake table test and triaxial test, to desaturate soil from the experimental results. Higher nitrate concentration in desaturation solution lower the degree of saturation was achieved. They conclude that strength improves significantly where the degree of saturation reduces from 100 to 87.5 percentage. Gas-phase of microbial desaturated soil is stabling hydrostatic conditions and stress-strain response shown that increases in strength. "Hanifi et al. (2015) have analyzed the effect of CaCO3 precipitation in organic soil using the Sporosarina Pasteurii". The bacteria are cultured in urea nutrient agar medium". Organic soil sample are prepared for experimental work for the consolidation and direct shear test. Then the sample is oven-dried before the injection of the bacterial solution. After injection of solution at the rate of 20ml/min and cured for 12 hours before experimentation. The authors conclude that the local pH rise leads to more permeability reduced.

3.2 Advantages and Disadvantages in MICP

"The cost comparison of Bio stabilisation with convention method has been done by (Muynck et al.,

ISBN: 978-93-90214-19-8

2010)". Mainly, it depends upon the genus of bacteria used for the purpose and number of applications required for the field. Sometimes Bio-stabilisation could be done as value added to the traditional methods. Investment for microbial treatment is comparatively low with respect to conventional methods. Maintenance cost is not required. Sustainability suits this method at a great extent with production on the nontoxic substance in the soil. Microbial applications for crack treatment and Rehabilitation of historic monuments are commonly preferable. The treatment area has to be wet for the live production of calcium carbonate. Microbial stabilization efficiency is purely based on the production of calcium carbonate precipitation. But the dosage of nutrients used for the purpose increases more than the optimum leads to efflorescence and deterioration of the ability of calcite crystal in the voids. The process of formation of calcium carbonate is slow and more complex in nature. "Ravi et al. (2011) were made a study on cemented sand with various influencing factors like density, confining stress, stress anisotropy shear modulus". The authors have conducted the triaxial shear wave measurement test by varying the density 1.8 , 2.1, 2.25 g/cc at different percentages of cement and confining pressure and achieved significant results.

The results are shown that small strain shear modulus reaches a peak value before its movement of particle and also it is conclude. G max/ zigma failure was constant for all samples tested. "Khan et al. (2016) has made an attempt to control the soil erosion using the MICP method in the coastal region". The authors have compared the chemical used in ordinary grouting and bio-cementation in sustainable prospects and studied the auto repair by means of various agents like sunlight, seawater, bacteria through the MICP method. They suggested bio-cementation method for soil erosion in Bangladesh in the coastal regions. "Dejong et al. (2013) were analyzed bio cemented and an untreated samples of Ottawa sand with X-ray tomography". The authors conducted the experimental work in triaxial shear compression test by applying strain at a different rate and seen localized strain area with a spatial resolution of 15-micron meter. For each strain incremental, porosity has been analyzed and shear band forming at 50 degrees. For Uncemented and Bio treated samples have similar residual strength as same. The authors also observed that additional strength is lost if one bond between the grains of soil broken. They conclude that the shear strength of the soil is increased with a factor of 1.8.

"Dejong et al. (2013) have investigated to improve the potential of soil ecosystems through the multi-disciplinary level that squeezes the extract from biology and geochemistry". Authors analyzed that geochemical reaction is controlled by different parameters like mineral precipitation, the formation of biofilm gas and biopolymer. They also have undergone a detailed study of progress, opportunities, and challenges in this field. The slope stability of the terrain could improve by exploiting chemical. "Ng et al. (2012) were analyzed the different factors influencing the MICP like soil nutrients, bacteria type, bacteria cell concentration, fashion and distribution, temperature, pH, infection methodology". The authors has conducted the experiments in residual soil by treating with bacillus megatarium. Thus the shear strength and permeability of the soil sample are tested under the UCC and the falling head permeability test. They have achieved the results that urease forming bacteria utilized in MICP soil improvement with optimum nutrients.

3.3. Field Scale Vs Lab Scale

"Various researches have been carried out in microbial induced calcium carbonate precipitation at in situ and inside lab by the researchers like (Dejong et al., 2010; Whiffin et al., 2007)". Zooming of lab-scale to reality at in-situ has a little difficulty based on the geological nature of site and treatment process optimum conditions are the significant points to consider. In-situ influencing factors like microbes nature and efficiency, in-situ temperature, oxygen utilizing efficiency were determined by the overall output of the bio geo stabilization. Only with respect to an incremental increase of knowledge of work done by the researcher's current scenario should find the level to improve the process in ease and economical at the field scale. The majority of the research has been carried out in the genus sporosarcina pasteurii for microbial stabilization. When implementing the bacteria and nutrients used at the laboratory to the field scale is not suitable to the existing location. A few commercial products have been available in the markets like Corn steep liquor or Lactose mother liquor might be used as value-added to the other techniques.

“Cunningham et al. (2018) have made a demonstration on a close relationship between the lab-scale experimentation in different ratios and simulated model which reflects the field scale”. They have analyzed that fractured sandstone formation which is 340.8km below GL treated with MICP, now it is compared with the field scale . They also discuss that challenges in the field scale-like model domain size, initial X final boundary conditions and initial distribution of permeability. They adopt two different microbial injection methods. One is a number of injections in a long duration and secondly, a high number of injections in a short duration. They analyzed that injection pressure was increases during the MICP fracture test and reflects the same results in model predictions at the lab scale. The author was also studied about the liquefiable sand by treating with MICP grouting scheme. Then analyze solidified sandy samples in dynamic triaxial testing apparatus and also examined the performance of cyclic load. Then the corresponding results were compared to colloidal silica chemical grouting technology. From the mechanical performance of MICP samples, the authors concluded that hysteretic groups of light cementations were resembled likes loose sand, moderate cementation resembled likes dense sand and solidified by multiply treatment was more effective. The results indicate that the use of bacterial solution nutritive salt was reduced in the MICP grouting scheme and max solidification of sand was achieved in 1-2 days.

“Cheng et al. (2012) worked on the bacteria in mobilization in the unsaturated soil column”. The author conducted the soil column test at different height and different saturation conditions. Induced the calcite precipitation by means of percolation of bacterial and fixation solution into the unsaturated soil and monitored the unease actively ammonium nitrogen concentration and calcium carbonate content through the SEM. In order to avoid the bacteria washout in high porosity soil could be overcome by different through an interface of cementation and bacterial solution. They concluded that the result of these methods would be similar to the tradition of grouting techniques which did not create any impact on the environment. The authors have also arrived three times higher strength at low water content in the surface percolation method. “Dominique et al. (2012) were investigated to reduce the porosity of soil and rocks through microbes”. They conducted the sand column experiments by varying the injection strategies like parallel injection and staged infection of bacteria and cementation fluid. The results were declared that the amount of precipitation was more and the volume of pores were significantly reduced in the staged infection method up to 54 percent when compared to the parallel infection method (34 percentage).

3.3 A requirement of awareness in MICP

Biostabilisation using microbes which gives a sustainable solution and assists with societal needs. Conventional methods regarding soil stabilization have a concentration chemical reaction that would occur and manage to increase the density of soil through its chemical byproducts. Microbes are nowadays approached in inter disciplinary way and used in different fields such as geochemistry, civil and environmental engineering apart from microbiology. The study has been carried out about two decades before to set the compatibility between soil grain and microbes used for stabilization. “The basic requirement for biological stabilization which provides the answers to the following question like, How far the effectively improve the soil properties on a real scale? How long it would be efficiently microbes in an active state? (Dejong et al., 2010)”. Future studies should give information to overcome the limitations observed in the past and consider with features of analytical, numerical and experimental work so far carried out. Researchers should show more interest over the microbial Geotechnology which leads to a well-defined solution that makes our environment in sustainable.

“Fauriel and laioui, (2012) proposed the mathematical modeling to expand the bio grout infection, distribution of bacteria and biological reaction at porous medium”. The author has developed the balance equation for the solid and liquid phase in pore size rearrangement, distribution of infecting fluid and momentum balance in mixed-phase. They concluded that mathematical modeling could present the physical, chemical, biological process and couplings. Also cross-checked the result with the analytical solution. “Salwa et al. (2011) analyzed the role of urea’s activity in caco3 precipitation". The author has also described the poses of precipitation in different stages namely urea hydrolysis. Increasing the alkalinity of micro environmental surface exception of ca2+ ion and nucleation of crystal growth there are 2 metabolic path ways to produce precipitation which are autotrophic and heterotrophic. The authors also explain that concentration of ca2+ and co32- exceed the stability achieved super saturation and promoted a higher level of precipitation. Researchers were also proposed the technique which enriches urea's activity by adding the commercial milk powder or lysed activated sledge. The authors have conducted the urea's activity in the chemo static culture with and without yeast extract growth medium. They studied the role of ammonia urea nutrient in the production of ureolytic bacteria. This technique would be useful for the large-scale production of urease activity through microbial induced calcite precipitation.

3.4 Calcium Carbonate Polymorphs Forms

"The basic polymorphs crystal of calcium carbonate secreted by micro calcite, aragonite and vaterite (Navdeep et al., 2013) is shown in (Fig. 3)". These crystal forms were formed based on the bacterial structures, chemical strain, and composite of nutrient medium. "Malcolm et al. (2012) have proposed this study on how to regulate urease activity in ureolytic bacteria which has taken from six different soils". They have prepared the culture condition and media for each soil and measured the urease activity and proteins. The authors analyze that at least one cultivable micro organism from each soil for the production of urease activity. These kinds of indigenous bacteria are to precipitate calcite even in an ammonium environment.

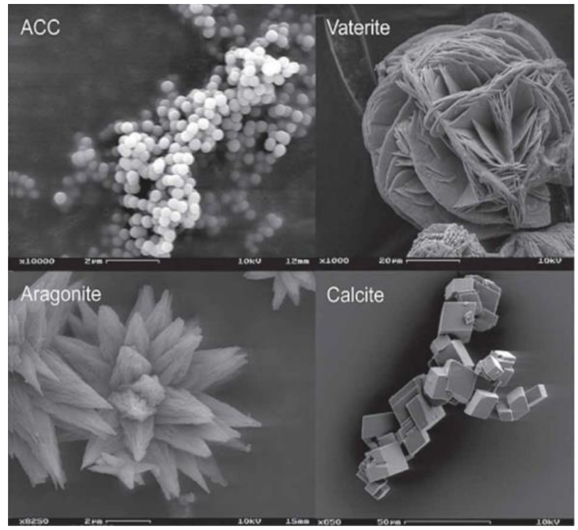

Fig. 3. Polymorphs of CaCO3

Referred from (http://www.ruhr-uni-bochum.de/sediment/forschung.html)

The characteristics of calcite crystal among the bacterial precipitation were stronger and more predominant than vaterite and aragonite. Various researchers analyzed the morphology study of bacteria were given (Table 3). "Dejong et al. (2017) analyzed by soil properties of sand treated with bio-cementation". They conducted that the test on the sand with different percentages of cementation in the range of high, medium and heavy and it was compared with the untreated sample in the triaxial test enabled with computer tomography scanning. All the tests were conducted at effective coifittress 100 kPa. The test results were shown that shear strength peak value at low internal strains compared to untreated samples and analyzed the polymorphs forms as calcite. "Okwadha et al. (2010) had a study on microbial carbonate precipitation at optimum conditions". The authors conducted the factorial experiments by varying the bacterial cell concentration and calcium concentration with urea of different compositions. They analyzed the factors like pH, NH4 generated, rate of urea hydrolysis, amount of CaCo3 precipitation. They concluded that optimum conditions for calcium and urea were 250mm. Ca2+ and 0.66mm urea with the bacterial cell concentration of 2.3x10^8 mL-1. The concentration of urea calcium and bacterial cell was more than the caco3 precipitation and rate of urea hydrolysis also more. "Qi et al. (2017) were

ISBN: 978-93-90214-19-8

analyzed the hardness and compressive strength of the bio-cemented sample with different bio cemented samples with different members of spraying". The authors has increased the density of sandy particles, to mitigate the air pollution at construction site through MICP.

"Paenibacillus bacteria" were used by the authors and it was cultivated in the sucrose medium. They have found the results of hardness, calcite content, porosity, micro structure and compressive content, porosity, microstructure and compressive strength of the soil samples with the effect of a number of spraying (1,3,5, and 7 respectively). About 73% increment in hardness and 26 % increment in compressive strength. He concluded that the effect of the number of spraying could increase the quality and concentration of micro-organisms. The secretion of cementation would have subjected to change. "Hui et al. (2012) investigated to increase the mechanical property of sandy soil through microbe cement. They prepared the soil sample by injected the microbial solution and fix the bacteria in 2 hours". Then the cementation fluid has been injected next to the microbial solution, then flow had been stopped for 6 hours to react during incubation time of 7 days. Then oven-dried at 60 degrees Celsius temperature and tested for mechanical properties and porous structure. The authors concluded that after the 7 days of treatment with microbe cement, which leads to increase in compressive strength at bottom region. The three-dimensional image of cemented sandstone was being analyzed by X-ray computed tomography.

CONCLUSIONS

The bio geo stabilization is one of the emerging techniques to improve the engineering characteristics of soil. Minerals are secreted biologically through microbes, and these are widely used in different applications like removal of contamination in waste water, construction materials and Paleo biology. The over view of the paper summarizes the various influencing factors for microbial induced calcite precipitation, biological treatment for different types of soil, merits, and demerits of this technology, field-scale difficulties, etc., Optimum condition for the different bacteria and various types of soil were achieved properly in the laboratory scale before implementing it into the field scale by the various researchers. An optimum condition always decides their exact proportion of the concentration of various mixtures like cementation, bacterial content. Developing colonies and effective production of bio minerals is one of the major challenges at the field scale. Future studies and investigations can be carried out to sort out the limitation of this method in the past two decades. "Commercialization of product requires 60 percentage high of existing method due to large volume production (Waechter et al., 1994)". To overcome all difficulties at field scale further investigations are required in the quantification of bacteria in soil different soil mixtures.

REFERENCES

Achal V., Mukherjee A., (2015), A review of microbial precipitation for sustainable construction, Construction Building
Materials, 93, 1224-1235.

Castanier S., LeMetayer G., Perthuisot J., (1999), Ca-carbonate precipitation and lime stone genesis the micro bio
geologist point of view, Sedimentary Geology, 126, 9–23.

Chang I., Cho G., (2018), Shear strength behavior and parameters of microbial gellan gum-treated soils: from sand to clay
Acta Geotechnica, 4, 1-15

Cheshomi A., Mansouri S., Amoozegar M., (2018), Improving the Shear Strength of Quartz Sand using the Microbial
method, Geomicrobiology Journal, On line at: https://doi.org/10.1080/01490451.2018.1462868.

Cheng L., Cord R., (2012), In situ soil cementation with ureolytic bacteria by surface percolation, Ecology Engineering,
42, 64–72.

Cheng L., (2012), Innovative ground enhancement by improved microbially induced caco3 precipitation technology, Ph.D.
Thesis, Murdoch University, Australia.

Cheng L., Cord R., (2012), In situ soil cementation with ureolytic bacteria by surface percolation, Ecology Engineering,
42, 64-72.

Cheng L., Cord R., (2013), Selective enrichment and production of highly urease active bacteria by non-sterile (Open)
chemostat culture, Journal of Industrial Microbiology & Biotechnology, 40(10), 1095-1104.

Cheng L., Cord R., Shahin M ., (2013), Cementation of sand soil by microbially induced calcite precipitation at various
degrees of saturation, Canadian Geotechnical Journal, 50(1), 81–90.
Cheng L., Cord R., (2014), Upscaling effects of soil improvement by microbially induced calcite precipitation by surface
percolation, Geomicrobiology Journal, 31(5), 396-406.
Cheng L, Shahin A, Cord R, (2014), Bio-cementation of sandy soil using microbially induced carbonate
Precipitation for marine environments, Geotechnique, 64(12), 1010-1013.
Chi L., De Y., Shihui L., Tuanjie Z., Siriguleng Bai., Yu G., Lin Li., (2017), Improvement of geomechanical properties of
bio-remediated Aeolian sand, Geomicrobiology Journal, 35, 132-140.
Chu J., Ivanov V., Naeimi M., Li, B., Stabnikov, V., (2011), Development of microbial geo technology in Singapore.
Proceeding of Geo frontiers advances in Geotechnical Engineering, ASCE Geotechnical Special Publication, 211,
4070–4078.
Cunningham A., Class H., Ebigbo A., Gerlach R., Phillips A., Hommel J., (2018), Field-scale modeling of microbially
induced calcite precipitation, Computational Geosciences, On line at https://link.springer.com/article/10.1007/s10596-018-9797-6?shared-article-renderer.
Dawoud O., Chen Y., Soga K., (2014), Microbial Induced Calcite Precipitation for Geotechnical and Environmental
Applications, New Frontiers in Geotechnical Engineering GSP, 243, 11-18.
DeJong J. T., Fritzges M. B., Nusslein K., (2006), Microbial induced cementation to control sand response to undrained
shear, Geotechnology and Geoenvironmental Engineering, 132(11), 1381–1392.
Dejong J., Burbank M., Kavazanjian E., Weaver T., Montoya M., Hamdan N., Bang S., Esnault A., Tsesarsky M., Aydilek
A., Ciurli S., Tanyu B., Manning C., Larrahondo J., Soga K., Chu J., Cheng X., Kuo M., Qabany A., Seagren A., Van Paassen A., Renforth P.., Laloui., Nelson C., Hata T., Burns S., Chen Y., Caslake F., Fauriel S., Jefferis S., Santamarina C., Inagaki Y., Martinez B., and Palomino A., (2013), Biogeochemical processes and geotechnical applications: Progress, opportunities and challenges, Geotechnique, 63(4), 287-301.
DeJong J., Mortensen B., Martinez C., Nelson D. C., (2010), Biomediated soil improvement, Ecology Engineering, 36,
197–210.
DeJong J., Soga K., Banwart A., Whalley R., Ginn T., Nelson C., Mortensen M., Martinez, C., Barkouki, T., (2011), Soil
engineering in vivo: harnessing natural biogeochemical systems for sustainable, multi-functional engineering
solutions, Journal of the Royal Society , 8(54), 1–15.
DeJong J., Gomez M., Waller J., Viggiani G., (2017), Influence of Bio-Cementation on the Shearing Behavior of Sand
Using X-Ray Computed Tomography, Geotechnical Frontiers, 280, 871-880.
Dominique J., Erica M., Vernon R., (2012), Microbially mediated plugging of porous media and the impact of different
injection strategies, Ecological Engineering , 42, 270– 278.
Donovan M., Mohamed A., Cheng L., (2016), State of the art review of bio-cementation by microbially induced calcite
precipitation (MICP) for soil stabilization, Geomicrobiology Journal, 34, 524-537.
Gebrehiwet A., George D., Yoshiko F., Mikala S., Smith R., (2012), The Effect of the CO32- to Ca2+ Ion activity ratio on
calcite precipitation kinetics and Sr2+partitioning, Geochemical Transaction,13, 1-11.
Fauriel S., Laloui L., (2012), A bio-chemo-hydro-mechanical model for microbially induced calcite precipitation in soils,
Computers and Geotechnics, 46, 104–120.
Hataf N., Jamali R., (2018), Effect of Fine-Grain Percent on Soil Strength Properties Improved By Biological Method,
Geomicrobiology Journal, 35 (8), 695-703
Hanifi C., Waleed S., Ibrahim H., (2015), Effect of bacterial calcium carbonate precipitation on Compressibility and shear
strength of organic soil, Soils and Foundations, 55 (5), 1211–1221.

Han Z., Cheng X., Ma Q., (2016), An experimental study on the dynamic response for MICP strengthening liquefiable sands, Earthquake Engineering and Engineering Vibration, 15, 673-679.

He J., Chu J., Wu S., Peng J., (2016), Mitigation of soil liquefaction using microbially induced desaturation, Journal of Zhejiang University-science a, 17 (7), 577-588.

Hideaki Y., Debendra N., Kazuyuki H., Mitsu O., (2012), Experiments and predictions of physical properties of sand cemented by enzymatically-induced carbonate precipitation, Soils and Foundations, 52(3), 539–549.

Hui R., Chun Q., Long L., (2012), Study on microstructure and properties of sandstone cemented by microbe cement, Construction and Building Materials, 36, 687–694.

Jianyun W., Yusuf E., Nico Boon., Nele B., (2016), Application of microorganisms in concrete: a promising sustainable Strategy to improve concrete durability, Applied Microbiology and Biotechnology, 100, 2993–3007.

Jonkers M., Schlangen E., (2008), Development of a bacteria-based self healing concrete, Tailor Made Concrete Structures, On line at https://www.researchgate.net/publication/267716612.

Khan H., Kawasaki S., Hassan R., (2016), Sand Solidification through Microbially Induced Carbonate Precipitation for Erosion Control: Prospects in Bangladesh, Journal of Environmental Science and Natural Resources, 9(1), 59-61.

Stress-deformation and compressibility responses of bio-mediated residual soils

Lee M., Ng W., Tanaka Y., (2013), Stress-deformation and compressibility responses of bio-mediated residual soils, Ecological Engineering, On line at https://scholar.google.co.in/scholar?q=10.1016/j.ecoleng.2013.07.034&hl=en&as_sdt=0&as_vis=1&oi=scholart.

Lin D., Lin K., Hung J., Luo L., (2007), Sludge ash/hydrated lime on the geotechnical properties of soft soil, Journal of Hazardous Materials, 145, 58–64.

Maheswaran S., Dasuru S., Ramachandramurthy A., Bhuvaneshwari B, Ramesh Kumar V., Palani, Nagesh S., Iyer, Sarayu Krishnamoorthy R., Sandhya S., (2014), Strength improvement studies using new type wild strain Bacillus cereus on cement mortar, Current Science, 106(1), 50-57.

Martinez C., DeJong J., Ginn T., Mortensen B., Barkouki T., Hunt C., Tanyu B., Major D., (2013), Experimental optimization of microbial induced carbonate precipitation for soil improvement, Journal of Geotechnical and Geo Environmental Engineering, On line at https://www.researchgate.net/publication/272090556_Bio-mediated_Soil_Improvement_Field_Study_to_Stabilize_Mine_Sands.

Malcolm B., Thomas J., Weaver L., Green C., Ronald L., (2011), Precipitation of Calcite by Indigenous Microorganisms to Strengthen Liquefiable Soils, Geo microbiology Journal, 28(4), 301-312.

Malcolm B., Thomas J., Barbara C., Ronald L., (2012), Urease Activity of Ureolytic Bacteria Isolated from Six Soils in which Calcite was precipitated by Indigenous Bacteria, Geomicrobiology Journal, 29(4), 389-395.

Montoya B., Feng K., Shanahan C., (2013), Bio mediated soil improvement utilized to strengthen coastal deposits, Proceedings of the 18th international conference on soil menchanics and Geotechnical Engineering, 18, 2565-2568.

Muynck W., Belie N., Verstraete W., (2010), Microbial carbonate precipitation in construction materials: A Review, Ecology Engineering, 36(2), 118-136.

Ng S., Lee L., Hii L., (2012), An overview of the factors affecting microbial-induced calcite precipitation and its potential application in soil improvement, World Academy of Science, Engineering and Technology, 6(2), 683-689.

Ng W., Lee M., Tan C., Hii S., (2013), Improvements in engineering properties of soils through microbial-induced calcite precipitation, Journal of Civil Engineering, 17(4), 718-728.

Navdeep D., Sudhakara M., Abhijit M., (2016), Significant indicators for biomineralization in the sand of varying grain sizes, Construction and Building Materials, 104, 198–207.

Navdeep D., Reddy S., Mukherjee A., (2013), Biomineralization of calcium carbonates and their engineered Applications, A review, Frontiers Microbiology, 4, 1-13.

Okwadha G., Li J., (2010), Optimum conditions for microbial carbonate precipitation, Chemosphere, 81 (9), 1143-1148.

Paulo J., Freitas D., Joao F., Carmona., (2016), Effect of Soil Type on the Enzymatic Calcium Carbonate Precipitation Process Used for Soil Improvement, Journal of Materials in Civil Engineering, On line at https://ascelibrary.org/toc/jmcee7/29/4

Pakbaz S., Alipour R., (2012), Influence of cement addition on the geotechnical properties of an Iranian clay, Journal of Applied Clay Sciences, 10, 67–68.

Pakbaz S., Farzi M., (2015), Comparison of the effect of mixing methods (Dry vs. Wet) On mechanical and hydraulic properties of treated soil with cement or lime, Journal of Applied Clay Sciences, 11, 105–106.

Qabany A., Mortensen B., Martinez B., Soga K., De Jong J., (2011), Microbial carbonate precipitation correlation of S-wave velocity with calcite precipitation, Proceeding of Geofrontiers, Advances in Geotechnical Engineering, 211, 3993–4001.

Qi Z., Chun Q., (2017), Stabilization of sand particles by bio-cement based on CO2 capture and utilization: Process, mechanical properties and microstructure, Construction and Building Materials, 133, 73–80.

Qian C., Qing F., Rui X, (2010), Cementation of sand grains based on carbonate Precipitation induced by microorganism, 53(8), 2198–2206.

Ravi S., Christoper B., Michael J., (2011), Relationship between shear wave velocity and stresses at failure for weakly cemented sands during drained triaxial compression, soils and foundations, 51, 761-771.

Ramachandran S., Ramakrishnan V., Bang S., (2001), Remediation of concrete using micro-organisms, ACI Materials Journal, 98, 3-9.

Rahim S., Ghassem H., Ehsan Nikooe., Niazi A., (2017), Biological Stabilization of a Swelling Fine-Grained Soil: The Role of Microstructural Changes in the Shear Behavior, Iran Journal of Sci Technological Trans Civil Engineering, 41, 405–414.

Rodriguez C., Rodriguez M., Ben K., Gonzalez-Munoz, M.T., (2003), Conservation of Ornamental stone by Myxococcus Xanthus induced carbonate biomineralization, Applied Environmental Microbiology, 69 (4), 2182–2193.

Salwa T., (2011), Ureolytic bacteria and calcium carbonate formation as a mechanism of strength enhancement of Sand. Journal of Advanced Science Engineering Research, 1, 98-114.

Shiping W., Hongpeng C., Zhenglong J., Hao L., Hao H., Nianqiao F., (2015), Bio mineralization processes of Calcite induced by bacteria isolated from marine sediments, Brazilian Journal of Microbiology, 46(2), 455-464.

Sungsik P., Sun C., Hyun N., (2014), Effect of Plant-Induced Calcite Precipitation on the Strength of Sand, Journal of Materials in Civil Engineering, 26(8), 06014017. On line at https://doi.org/10.1061/(ASCE)MT.1943-5533.0001029.

Soon N., Lee, L., Khun T., Ling, H., (2013), Improvements in engineering properties of soils through microbial-Induced calcite precipitation, Journal of Civil Engineering, 17(4), 718-728.

Stocks S., Galinat J., Bang S., (1999), Microbiological precipitation of CaCO3, Soil Biology and Biochemistry, 31(11), 1563–1571.

Varenyam A., Abhijit M., (2015), A review of microbial precipitation for sustainable construction, Construction and Building Materials, 93, 1224–1235.

Waechter B., Gertsson U., Sundin P., (1994), Prospects for Microbial Stabilization in Closed Liquid Hydroponic Cultures of Tomato, Developments in Plant and Soil Sciences, 61, 381-383. On line at https://link.springer.com/chapter/10.1007/978-94-011-1158-4_41.

Whiffin S., Leon A., Van P., Marien P., (2007), Microbial Carbonate Precipitation as a Soil Improvement Technique,
Geomicrobiology Journal, 24(5), 417-423.

Whiffin S., (2004), Microbial CaCO3 precipitation for the production of bio cement, Sc.D. thesis, School of
Biological Sciences and Biotechnology, Murdoch University, Perth, Australia.

Zhong L and Islam M., (2017), A new microbial plugging process and its impact on fracture remediation, Society of
Petroleum Engineers, On line at https://www.researchgate.net/publication/314777303
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Assessment of Energy Dissipation Capacity of Steel Moment Resisting Frames under the Effect of Earthquake

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Abstract - In recent years, earthquake engineering was introduced and showed the path for energy concepts, these concepts have applications in evaluating the vulnerability of the structures under earthquake vibrations and also in optimization design. Now-a-days, energy dissipation capacity is estimated by either empirical equations or experimentally for the study. The numerical analysis which is considered difficult to use in practice. In the present study, nonlinear dynamic analysis is obtained to investigate the distribution of damagein the structure and also to find out the maximum story drift and maximum displacement. The main aim of this study is to evaluate the energy dissipation capacity of steel moment resisting frames under earthquake motions. The more the structure height increases the dissipations capacity increases. The stress levels at top stories are high which are controlled by potential and kinetic energy and balanced with damping.

Keywords: Moment resisting frames, Seismic design, Non- linear Dynamic analysis, Energy dissipation capacity.

INTRODUCTION

Assessing the structural behaviour at times of earthquake, plays an important role in earthquake engineering. One of the concepts found by researchers in recent years was Energy Concept. This concept was introduced by Housner [1] in which he proposed energy method based on limit design. His affirmation is that the absorption of energy against earthquake was said to be the safety factor of its own building and the Energy input during the earthquake will lead to some parameters like kinetic and potential energies. Energy dissipation is mostly considered in seismic and dynamic analysis in which hysteric behavior was represented by viscous damping and global damping of the structure. Gerami and Abdollahzadeh [2] carried out a research on energy dissipation for steel frames at near and far fault regions and conclusion that damping plays powerful role in energy dissipation for high rise structures. In seismic design methods the parameters are earthquake durationand frequency, some of the structural requirements are hysteresis behavior, damping and ductility. Gholamreza Abdollahzadeh, Hadi Faghihmaleki [3], concluded that hysteric energy at lower stories will be higher when compared to higher stories. Hysteric energy shows the level of damage in a structure but cannot specify the damage at different locations or parts of structure, where this energy is wasted when the structural members reachits beyond yielding point. The whole behavior is said to be inelastic behavior, which is to be taken care when structure issubjected to Non-linear dynamic analysis. Benavent [4] defined a model to show the damage level of the structural members and hysteresis behavior at different earthquake records, where he concluded that the damage occurs due to inter story drift and hysteric energy, Story drift is one the causes for waste of energy. Idels, Lavan [5] defined about the Steel Moment resisting frames (SMRF), in their study they said that SMRF have a great capacity on holding the dissipated energy and have resistance against the lateral forces (earthquake forces). This study is to focus on energy dissipation capacity of steel structures using seismic design of nonlinear dynamic analysis, whichshows the energy wasted through inelastic behavior and the damping forces that are balanced when the input energy is absorbed into the structure at times of earthquake. This paper also focused on hysteric behavior of the modelled steel structures. The main objective of this paper is to find out the maximum story drift, maximum story displacements and the cumulative energy dissipation capacity for both the structures.

MODELLING

The selected models for research are 5 and 10 story steel structures. They were analyzed and designed by using ETABS software on the basis of Indian Standard codes (IS code 800:1987 for steel, IS code 1893:2002 for earthquake). All the material, section properties and loads of the selected structures were taken under IS code as mentioned in table.1 and table 2.

Fig 1. Plan of steel structures

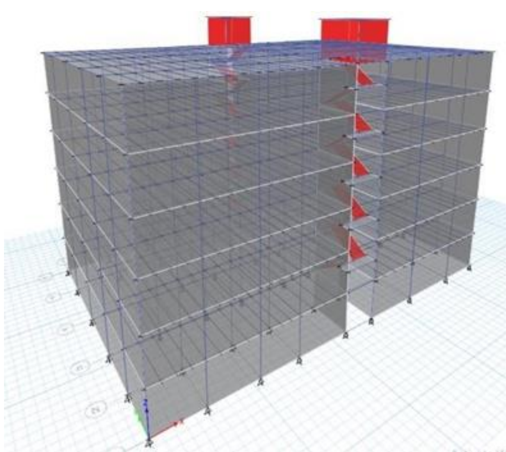


Fig 2. 3D model of 5 story building

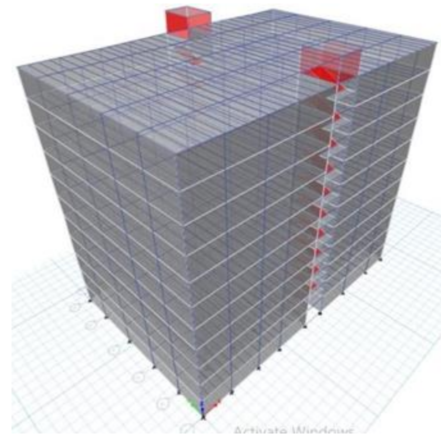


Fig 3. 3D model of 10 story building

Details of preliminary data:

- For steel Fe250
- Reinforcement HYSD 415

Table 1. Structural details of 5 story building:

S.no	Structural element	Width (mm)	Depth (mm)	Flange thicknes s(mm)	Web thicknes s(mm)
1	Beam	200	300	30	30
2.	column	350	600	60	60

Table 2. Structural details of 10 story building:

S.no	Structural element	Width (mm)	Depth (mm)	Flange thickness (mm)	Web thickness (mm)
1	Beam	250	350	30	30
2.	column	450	750	75	75

Structural detailing has been considered on the basis of IS code. The story height for two steel structures were, 3m and spans vary as shown in plan (fig.1).

ANALYSIS AND DESIGN IN ETABS:

For analyzing the selected steel structures Time history, Non- linear dynamic analysis was considered. All the buildings were created using ETABS software which gives accurate results.

3.1 PARAMETERS CONSIDERED FOR BUILDING:

ISBN: 978-93-90214-19-8

For this design,

- Zone selected was II with zone factor 0.1,
- Type of soil selected was 2
- Reduction factor as 5
- Damping as 5%.
- Dead load and Live load are given as per IS 875 (Part I) and (Part II) 1987, respectively. Seismic Loading is taken as per IS 1893:2002
- Earthquake load (EQ X, EQ –X, EQ Y, EQ -Y) were considered under the basis of Indian Standard codes(IS). Other loads like snow and wind were not considered in the seismic design.

Plastic hinges play an important role in Energy dissipation, they help in finding out whether the structure can withstand or not when effected by heavy lateral forces. When they were applied at the ends of the beams energy dissipation will be occurred in the building. In this paper the structures were analyzed for Elcentro time history function and plastic hinges were applied. All the members in the steel structure were passed for all the applied loads, material and section properties given. The created models were shown in fig.2 & fig.3

3.2 DEFORMED SHAPE OF 5 & 10 STOREY BUILDING:

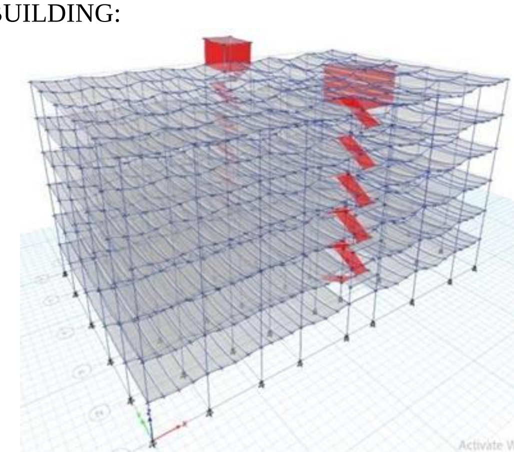


Fig. 4, 5 story building

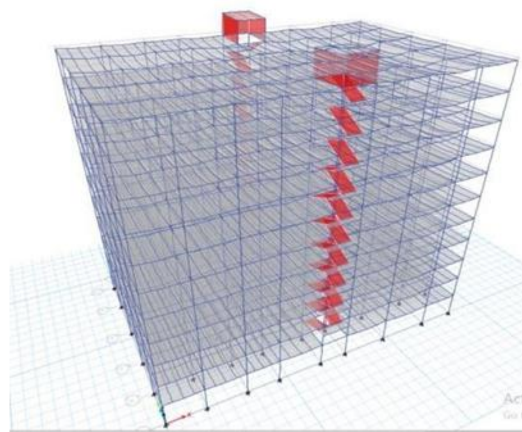
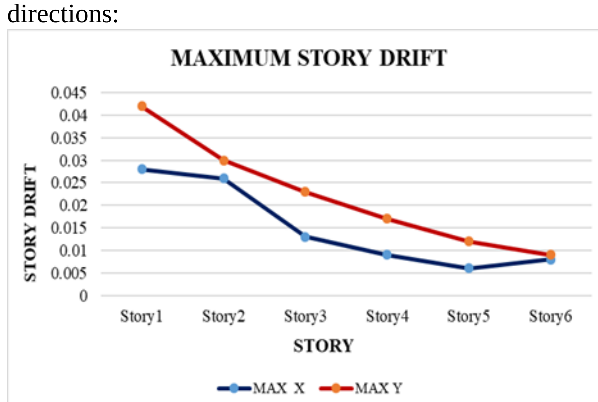


Fig.5, 10 storey building

RESULTS & DISCUSSION

4.1 FOR 5 STORY BUILDING:

Maximum story drift for Time history in X & Y directions:

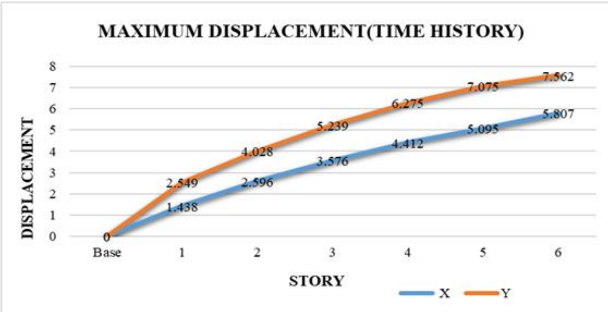


Graph.1 story drift for 5 story building

Maximum Story drift for time history analysis in X and Y directions were under the limit. According to the IS code limit check is done using the formula (0.004h), "h" is the height of the story.

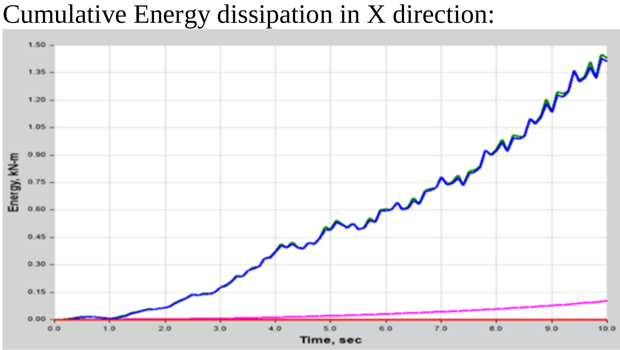
Maximum displacement for Time history in X & Y directions:

ISBN: 978-93-90214-19-8



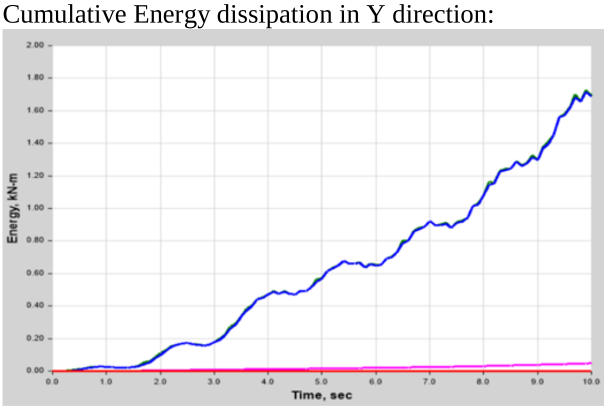
Graph.2 story displacement for 5 story building

Cumulative Energy dissipation in X direction:



Graph.3 energy dissipation TH-X direction

Cumulative Energy dissipation in Y direction:

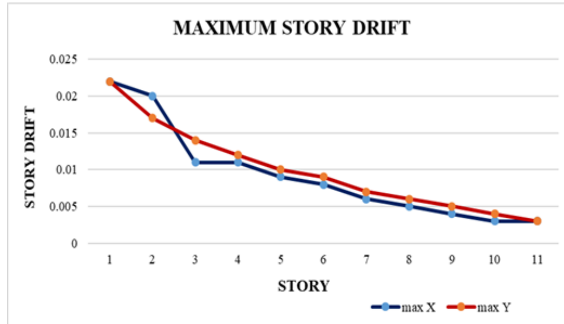


Graph.4 energy dissipation TH-Y direction

Energy dissipation for time history X & Y direction graphs were shown above, where the blue colour area is potential energy and the pink colour area is global damping of the structure. Damping energy helps in balancing the building when the input energy is absorbed from the lateral forces.

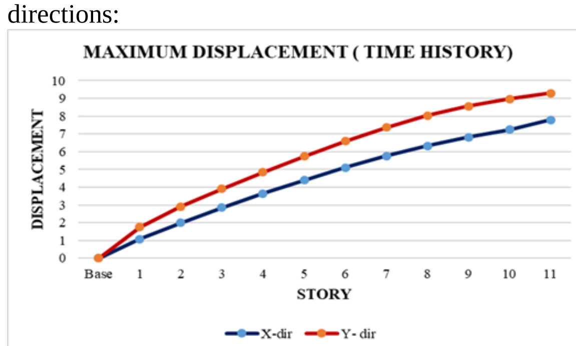
4.2 FOR 10 STOREY BUILDING:

Maximum story drift for Time history in X & Y directions:



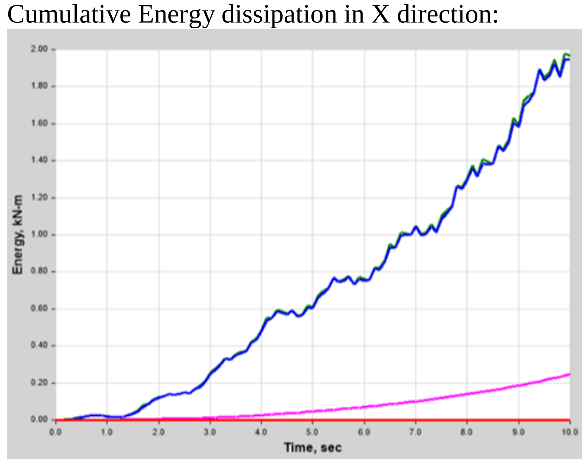
Graph.5, story drift for 10 story building

Maximum displacement for Time history in X & Y directions:



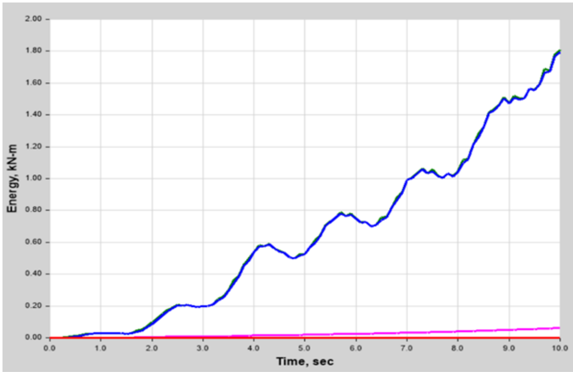
Graph.6, story displacement for 10 story building

Cumulative Energy dissipation in X direction:



Graph.7, energy dissipation TH-X direction

Cumulative Energy dissipation in X direction:



Graph.8 energy dissipation TH-Y direction

4.3 DISCUSSION:

Story drift and story displacements were checked using the formulas based on code book. 0.004h and H/500,

where "h" is height of story and "H" is height of building. When the structure is subjected to the lateral forces like earthquake dissipation occurs. The more the structure height increases the more dissipations capacity increases. For every structure kinetic energy, potential energy, damping force and viscous damping is present. Whenever the building is effected by earthquake, stresses increase in structure and cause local failures, these stresses can be balanced by maximizing the global damping in order to decrease the potential energy or kinetic energy. Then energy dissipation will be maximum and structure will be safe from total collapse.

CONCLUSION:

From the time history Non-linear dynamic analysis for the selected steel structures 5 and 10 stories, Maximum story drift, maximum story displacement and cumulative energy dissipation were studied. In this analytical study the following results were obtained.

- Maximum story drift for 5 story building was 0.042mm & Maximum story drift for 10 story building was 0.022mm, where at lower stories drift has been exceeded the limit and can be reduced by reducing the depth of beams
- Maximum story displacements obtained were acceptable but also can be reduced by providing shear wall to the buildings.
- Energy dissipation in the buildings are balanced by damping whereas for 5 story building it was 8% in X direction and even less in Y direction.
- For 10 story building the global damping was 18% in X direction and even less in Y direction.
- One thing which was observed was the cumulative energy dissipation capacity was less in 5 story building when compared to 10 story, it can be increased by reducing the stresses which are in the form of potential energy and kinetic energy.

REFERENCES:

1. G.W. Housner, Limit design of structures to resist earthquake, in: First World Conference on Earthquake Engineering, Berkeley, California, 1956.
2. Mohsen Gerami and Davood Abdollahzadeh, Numerical Study on Energy Dissipation of Steel Moment Resisting Frames under Effect of Earthquake Vibrations, Islamic Azad University of Pardis, Tehran 16555-135, Iran, 2013
3. Gholamreza Abdollahzadeh, Hadi Faghihmaleki, Comparing Hysteretic Energy and inter-story drift in steel frames with V-shaped brace under near and far fault earthquakes, Tabari University of Babol, Iran, 2016.
4. Benavent- climent, an energy based damage model for seismic response of steel structures, earthquake engineering, struc. Dyn. 36 (2007), 1049-1064.
5. O. Idels, O. Lavan, Performance based formal optimized seismic design of steel moment resisting frames, Haifa, Israel, 2019.
6. Jiwook Shin and Kihak Lee, Seismic Evaluation of Steel Moment Resisting Frame Buildings with Different Hysteresis and Stiffness Models, Seoul. Korea
7. Shuo Dong, Chengwei Huang, Modal Analysis on Steel Frame-energy Dissipation Support Structure, China, 2014.
8. Farshad Taiyari, Antonio Formisano, Seismic Behaviour Assessment of Steel Moment Resisting Frames Under Near-Field Earthquakes, International Journal of Steel Structures, Korean, 2019.
9. Jae-Guen Yan, Yong-Boem Kim, Evaluation of the Energy Dissipation Capacities of Beam-to-Column Moment Connections for Steel Frames, Inha University, South Korea, 2015.
10. H. PARK and T. EOM, Energy dissipation capacity of flexure-dominated reinforced concrete members, 13th World Conference on Earthquake Engineering, Canada, 2004.

 ISBN: 978-93-90214-19-8

11. Yu Jiao, Satoshi Yamada, Evaluation of plastic energy dissipation capacity of steel beams suffering ductile fracture under various loading histories, Chiba 263-8522, Japan, 2011.

12. H.K. Miyamoto, A.S. Gilani, State of the art design of steel moment frame buildings with dampers, 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.

13. Theodore L. Karavasilis, Nikitas Bazeos, Behavior Factor for Performance-Based Seismic Design of Plane Steel Moment Resisting Frames, Patras, Greece, 2007.

Effect of Admixture on Properties of High Strength Concrete a Review

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Abstract - High performance concrete (HPC) is fast getting allowed for a wide range of avail in the construction of concrete building. It is made material for specific consumption and having advantageous properties like high strength, high durability, workability and economy. High constructability as compared to the lineal type of normal strength concrete.

The scope of the present study is to the effect of mineral admixture like silica fume, metakaolin, GGBS and fly ash towards the performance of HPC. An effort has been made to focus on the mineral admixtures towards their pozzolanic reaction, contribution towards strength properties, mix proportioning and self-compact ability. The main article of this study to retrace the physical properties of high-performance concrete (HPC) like strength, elasticity, plasticity using fly ash, silica fume, GGBS as mineral admixture. HPC is the latest evolution in concrete and more consumed in the general projects. The HPC also resist the attack of chemical like chlorides and sulphates. The uses of these admixtures increase and improve the properties of concrete like strength and durability. High performance concrete for construction especially for multistory building has become very common in industricilized and developing concrete. Porosity and pore size were reduced with the addition of the different supplementary cementitious materials. The volume of mesopores in the range of 15-30nm is notably increased for High strength concrete containing supplementary cementitious materials, whereas the percentage of macropores is significantly reduced.

Keywords: High performance concrete, mineral admixtures, fresh concrete, strength.

INTRODUCTION

High performance concrete is that type of concrete which give the best performance and acceptable result which cannot be achieved by normal concrete. High performance concrete is widely used in the large-scale project high durability, large flow ability high workability, self-compacting, easy mixing, high modulus of elasticity higher flexural strength, low permeability resistance to chemical attack cost effective and environment friendly high-performance concrete is concrete that has been designed to be more durable and its necessary, stronger than conventional concrete. Chemical composition determiner the role of mineral admixture in enhancing properties of concrete. Different materials with pozzolanic properties such as fly ash (FA) ground granulated blast furnace slug (GGBS), silica fume (SF) high reactivity met kaolin (HRM), have been widely used as supplementary cementitious material in the production of high-performance concrete. Fly ash and silica fume act as pozzolanic material as well fine fillers thereby the microstructure of the hardened cement matrix becomes denser and stronger. It does not grant any strength to it but act as an intense activator to avail the early age strength. Such application not only help to reform the strength and durability indications of high-performance concrete but will also help to determine more of the industrial by product which are by product which are major environmental threats. The use of water reducing admixture or super plasticizer high performance concrete has low water cement ratio (W/C) and low water binder ratio (W/B) the use of mineral admixtures such as fly ash, silica fume, metakaolin etc. has avail the attention worldwide over recent years because with the use of certain percentage it will improve and enhance varies properties of concrete in both fresh and harden state. Silica fume makes concrete more cohesive so that it avoids segregation and bleeding. And important thing is that all mineral admixture which I used in my review are industrial by products they help in obtaining both higher performance and economy HPC concretes are usually designed using materials other than cement alone to achieve this requirements ,like fly ash (from the cold burning process),ground blast furnace slag (from the still making process,) or silica fume different amounts of this materials are combined with Portland cement in varying percentages depending on the HPC requirements.

MATERIAL AND METHOD

To evaluate the High strength concrete, compressive strength, split tensile strength, and flexural Strength have been studied in this investigation.

Materials: High performance concrete is made of cement, Fly ash, GGbs, silica fumes, some mineral Admixtures.
Cement: Ordinary Portland cement 53 grades.

Mineral Admixtures

Fly Ash: Fly Ash is a byproduct of the deflagration of pulverized coal in thermal power plants. It is recapture as a fine dust by mechanical extractors, electrostatics precipitators or fabric filters. Fly ash can include into concrete ether blender with cement or directly introduce as an additional cementitious material at the concrete mixing plant. Typical application pumped or in super plasticizer concretes, particularly where heat of hydration is considered to be a problem. The introduction of Fly Ash as effects on many properties such as workability, hydration, strength development shrinkage heat evaluation and durability. The includes of Fly Ash in the concrete mix reduced the water contain require to produce a certain level of workability.

Silica Fume: Silica Fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most remunerative uses for silica fume is in concrete. Because of its chemical and physical competency, it is a great deal reactive pozzolan. concrete inclusive silica fume can have very high strength and can be very enduring. Silica Fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete manufacture. Placing, finishing, and curing silica fume concrete solicit exclusive consideration on the part of the concrete contractor. High strength concrete is a very economical material for carrying vertical loads in high rise building.

GGBS : Ground granulated blast furnace slag is procured by quenching molten iron slag (a byproduct of iron and steel making) from a blast furnace in water or steam to produce a glassy, granular product that is then scrawny and land in to a fine powder, ground granulated blast furnace slag is highly cementitious and high in CSH (calcium silicate hydrates) which is a strength enhancing compound which reform the strength durability and appearance of the concrete.

Metakaolin : metakaolin is the anhydrous calcined from the clay mineral kaolinite. Minerals that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain, the particle size metakaolin is smaller than cement particles, but not as fine as silica fume.

LITERATURE REVIEW

Hassan K,E. Cabrera J,G. and Maliehe (2000) In this research paper studies shown that, the physical properties of pure limestone aggregate (water absorption, loss –angles test) were superior to those of crystalline and marl limestone aggregate. How were, the bulk specific gravity of pure limestone aggregate was more than that of the later aggregates. The Ace load of HPC with net limestone aggregate was more than that of crystalline and marl limestone aggregate. the increasing unit weight due to apparent specific density of pure limestone (2690kg/m3), reaching unit weight up to 2530kg/m3.HPCwith pure limestone aggregate shows the best compaction characteristics and strength properties this is results of the intrinsic aggregate properties. the pure limestone shows stronger debentures with the with cement dope this later increase the adhesion force of a hereof reform the attribute of the interfacial transition zone, HPC with ggbfs with mineral admixture have good mechanical cretic similar than the one obtained with silica fume therefore can be recommended to exploitation ggbfs as mineral admixture formulation of HPC & it can be substituted the silica fume by blast furnaces slag.

Ali Alsalman, Canh N, Dang and W.Micah Hale (2017), In this research paper studies shown that, in Curing regime greatly effect on early gain in compressive strength of concrete leading to strength more than 100Mpa.Curing regime and use of admixture were useful to increase mechanical and environment performance of conventional concrete. Use of different fine materials can make a better compact mix for high-performance of conventional concrete. The use of fine materials decreased voids in concrete which resulted in high resistance to ingress of water, moisture, co2, etc.The maximum compressive strength can be obtained more than 200Mpa by controlling various parameters like water –cement ratio. admixtures etc. Along with different curing method as per requirement. Use of 5%silica fume and 30%fly Ash contributed more to short- and long-term properties of concrete. Use of Admixture increase density of concrete, which in turns increase the compaction to Avoid ingress of any foreign agents inside concrete.

M.D.A. Thomas, M.H. Shejata, S.G. Sheshiprakash, (2000) In this research paper studies shown that, it is studied that the constituents of HSC have been discuss it is noted that the necessary ingredients making the concrete such as fly ash, slag and silica fume are mostly industrial by products which are otherwise wasted in land- fills. this should be considered to words recognition of HSC as an environmentally friendly material. The main Engineering properties of HSC reviewed in the paper. during the past few years, high strength concrete HSC has been generating increased interest among civil and structural engineering the expansive commercial use of this relatively new structure material can be explained partially by the life cycle cost execution ratio it offers ,as well as its outstanding engineering competency, such as higher compressive and tensile strengths ,higher stiffness and better stability.

E.shaheen and N. G. Shrive,(2006) In this research paper studies shown that, it is observed that the compressive and split tensile strength of 30% shear force was better than other percentage of reactive powder concrete .the flexural strength was observed higher for 25% Shear force addition and it can be increased further by adding steel fiber. reactive powder concrete 25% SF was found to have lower penetration values than reactive powder concrete is more stable when corrosion interrupt is considered with other grade of high strength concrete reactive powder concrete shows expansive corrosion resistance significance compared to other concretes and may be effectively make use of in marine structure.

Reventh jagana , chintado vinodh kumar (2017) In this Research paper studies shown that, concrete with crushed granite aggregate of 2 mm developed higher compressive strength. This indicates two increase surface area and more homogeneous concrete.by trial error method the dosage of super plasticizer of 16.2litrs /mcu of cement or 7.8% that of water has given god results. the silica fume effect on the compressive strength seems to be more significant in the concrete with smaller size aggregates (2 mm) than coarse aggregate (6mm and 10 mm). when the coarse aggregate replaced by granite powder to make concrete mix workable, an increase in the w/c ratio from 0.32 to 2.038 and water by 25% was observed.

Kwan A.K.H., (2000), In this research paper studies shown that, From the past detailed studies, it can be inferred that, the ultra-high performance concrete give more strength than high performance concrete strength and durability characteristics are best in high performance concrete ,addition of mineral admixtures give more strength up to certain percentage of replacement, nondestructive testing NDT plays and important role for the reliable assessment of quality and integrity of concrete structures .

Beulah M. (2012), In this research paper studies shown that, it can be concluded that the residual compressive strength after 30,60,90days of acid immersion decreases with increasing water binder ratio. this may be due to porous transition zone leading to the formation of ettringite at higher water level. The addition of metakaolin increases the resistance to acid attack of high-performance concrete. optimum results obtained were at 10% replacement of cement by metakaolin. The residual compressive strength of high-performance concrete decreases with increasing age of acid immersion. the percentage decreases in compressive strength decrease rapidly up to 10%replacement cement by metakaolin as from then on words it decreases gradually. the percentage weight loss due to acid attack increase with the increasing water cement ratio.

Ch. KusumaKeerthi, K. Rajasjekhar,(2012) In this research paper studies shown that, It is observed that for beam the volume of steel decreased with increase in grade of concrete the volume of concrete for members increased with increase in grade of concrete the cost of concrete increased with increase grade of concrete the cost of steel decrease with increased the grade of concrete on a whole the cost of reinforcement cement concrete is less for M60 grade concrete when compared to M20 grade concrete, for columns the volume of steel decreased with increase in grade of concrete the volume of concrete for members also decrease with increase in grade of concrete the cost of concrete decrease with increase in grade of concrete the cost of steel decreased increase in grade of concrete .

S.O.Folagbade,Aigbavboa C.O.and Thwala W.D, (2016) In this research paper studies shown that,The study has calibrate the efficacy of fly ash ,silica fume and metakaolin on the air vulnerability of Portland cement concrete at equal water/cement ratios and and the following conclusions have been drawn ,coefficient of air permeability increased with increasing water/cement ratio and reduced with increasing curing age and compressive strength ,at equal water/ cement ratio, fly ash binary cement concrete have considerably higher coefficient of air permeability than Portland cement, concrete due to delayed pozzolanic reactivity. Silica fume and metakaolin binary cement concrete have coefficient comparable that of Portland cement at 28Days and lower coefficient at later ages due to their higher fineness resulting in better particle packing and improved pozzolanic reactivity.

Khaliq W, Kodur V (2013) ,In this research paper studies shown that,The bond between the High Strength concrete core and Normal Strength Concrete outer layer assumes to be strong enough to withstand the loading and avoid separation of two layers based on ambient compression test results however a strength reduction may exist for the 2L specimens due to the inert between the High Strength Concrete core and Normal Strength Concrete outer layer a plateau observed at around 100' degree Celsius to 150 degree Celsius , which is caused by the free water evaporation and diffusion inside the concrete pores .The effect of the inter face between High Strength concrete and Normal Strength Concrete on heat transfer in concrete is not significant. And the Normal Strength Concrete outer layer is proved effective in preventing the heat from attacking the High Strength concrete core. no explosive spalling was observed for all specimen.

N. A, Soliman and A. Tagnit-Hamou (2016), In this research paper studies shown that, They developed it as an innovative sustainable green , UHPC with low cost ,by using the ground glass powder (GP) .soliman and tagnit-hamou 150 used glass, powder as a replacement of quartz powder (QP) and cement keep silica fume SF AND quartz sand quantities the same in all mixtures .increasing flexural ductility and load carrying capacity of UHPC can be obtained by adding of steel fibers 2% of the UHPC by volume .concrete behavior was modeled by using concrete damaged plasticity modal. Two types of concrete were considered in the FE explication, normal strength concrete which depict the case of existing concrete construction and green ultra –high-performance concrete.

Deshmukh S.H.Bhusari , J.P, Zende,A.M.(2012). In this research paper studies shown that, From the above review's conclusions can be drawn that inclusion of glass fibre in specific dose achieve better workability, concrete volume stability and appropriate mechanical properties. Significant increase in compressive, split tensile and flexural strength with the use of glass fibre in various grade of concrete after 28 days of specimens have been observed. Glass fibre reinforced concrete can be demonstrated as emphatic supplementary structural materials with diminished density and has good immovability properties. The scope of using supplementary cementing materials to make environment friendly concrete as .an experimental work on fly ash with glass fibre is not properly reported. Based on literature review durability and mechanical properties of Glass fibre reinforced concrete (GRFC) with fly ash as supplementary cementing material can be studied as scope of this project. after the application of PUSH Y Load.

CONCLUSION

Metakaolin also performs well and the strength at quantum of improvement strength of concrete. Which is also close to the silica fume-based concrete. And also, The Addition of super plasticizers can also be implied to 70% increase the workability for the desired water content or decrease the water content for the desired workability.

Concrete with 10% of silica fume gives better strength at all water binder ratios and at all ages Mineral admixtures like Fly strength of the order of 80mpa or more.

High strength concrete provides a higher compressive strength, a higher modulus of elasticity, a higher tensile strength, 30% reduced Ash and silica fume are also used in high strength concrete to increase the compressive strength, the material like silica fume being a very fine powder of size under 20 in micron with cementitious properties binds well with cement to produce a stiff mix with high.

creep, and greater durability than normal strength concrete. It 40% reduces permeability of the concrete and it help attacks the concrete resist chemical.

The major application is the use of production of High strength concrete at water /cement ranging from 03 to 0.4 it has been found that the for most types of cement, superplasticizer improve the workability.

REFERENCES

[1] Patel V and Shah N, "A Survey of High-Performance Concrete Development in Civil Engineering Field", Open Journal of Civil Engineering 2013.69-79, pp.1-2.

[2] Muthu Kumar. T, Sirajudeen. K(January2016), "Experimental Investigtion on High Performance Concrete Using Alternate Materials".

[3] Dr.T.V.S.Vara Lakshmi, Prof.S.Adiseshu (05 February 2016), "A Study on Preparing on High Performance Concrete Using Silica Fume and Fly Ash".

[4] Deven Shinde , Mangesh chaudhari , Vaibhav Korgaonkar, Kunal Patil, Prof .Pritee Mistry(April 2016). "Detail Study of High PreformancebConcrete Using GGBS".

[5] M. Vijaya Sekhar Reddy ,I.V.Ramana Reddy, N. Krishna Murthy , Predicting the Strength properties of High Performance Concrete Using Mineral Admixture,ARPN Journal of Science and Technology,3(1),Jan,2013.

[6] Ayubelahi,Dr.Qaiseruz Zaman Khan ,Properties of High Performance Concrete with Supplementry Cementitious Materials, University of Engineering and Technology ,Taxilapakistan,December (2009).

[7] Debabrata Pradhan ,D. Dutta, Partha Ghosh,Properties of Exploration of Conventional concrete After Silica Fume Supplementary,International Jouranal of Innovative Research in Science ,Engineering And Technology ,3(1),January (2014).

[8] Key Willen and Christopher Boisvert-Cotulio (2015), "Material efficiency in the design of ultra-high performance concrete", Journal of Construction and Building Materials.

[9] Ahlborn, T., Peuse, E., Mission, D., and Gilbertson, C., (2008). Durability and strength characterization of ltra-high performance concrete under variable curing regimes. In Proceedings of the 2nd International Symposium on Ultra High Performance Concrete, Kassel, Germany.

[10] K. S. Al-Jabri, M. B. Waris, and A. H. Al-Saidy, " Effect of aggregate and water to cement ratio on concrete properties at elevated temperature," Fire and Materials, 2016

Production of Biogas (BG) From Kitchen Waste (KW) – a viable alternative for Energy Crisis

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Abstract - India is one of the fast developing countries and demand towards the daily energy needs also increasing rapidly due to population increase. Increase in consumption of non-renewable energy resources leads several problems like global warming, greenhouse effect and it leads to climate change. To overcome this energy crisis the only alternative is moving towards sustainable energy keeping this mind a trail research study was carried out in an educational institution by utilizing the waste generated from hostel mess (Mainly kitchen waste (KW)).This study was carried out in an educational institution with a student's strength of 5000.

A prototype of an anaerobic model of 2m^3 developed for the biogas(BG) production from the mixed KW generated from the hostel mess of the educational institution. It was developed for a trail study to establish a biogas(BG) plant in the educational institution campus. Education institution consists of 3 messes, out of which only one mess waste was considered for the trail research study. An anaerobic waste generation unit was fabricated using locally available material and container and the same has been utilized for generation of biogas(BG). Initially it was allowed to function for few days to attain the optimum gas general rate from the organic kitchen waste (KW). It was observed that from the average waste generation per person is 200g.

So approximately 500 to 1000kg of biogas(BG) can be generated out of 5000 students per day. Initially the biogas(BG) reactor was filled to 2/3rd of is capacity with kitchen waste and manure in the ratio 2:1. The gas generation rate reached the optimum level after 20 to 30 days .The composition of this biogas(BG) generated from the kitchen waste consists of nitrogen - 3%, Methane – 50% to 65%, Co^2 – 30% to 40%. The gas was collected in an air tight bag like container periodically and the same was used for cooking in the hostel mess and the slurry was used as manure. Based on the trail study it was proved that it is one of the viable options to overcome the energy crisis and sustainable technology in organic waste management.

Keywords: Kitchen Waste (KW), anaerobic model, composition of biogas (BG), Biogas(BG) slurry.

INTRODUCTION

It is clear that human activity is contributing to global climate change. One of the main causes of this change is the accumulation of carbon dioxide emitted by fossil fuels. As human development continues to increase and fossil fuels continue to run out, it is an undeniable fact that energy is sustainable; more energy must be replaced by fuel for society to maintain its quality of life. Instead of being a single source of energy to replace fossil fuels, the future of sustainable energy must rely on an integrated collection of renewable energy technologies. Another sustainable energy technology that is optimistic for the production of BG from organic waste. Biofuels are generally the most sought after in recent years. The energy found in other biofuels, such as corn ethanol, is about the same as the energy produced in the production process.Food waste refers to all types of food waste from restaurants, cafes and home kitchens. Kitchen waste forms an integral part of decaying waste and should therefore be recycled. The current study deals with the production of energy that differs from solid waste especially food waste. The objectives of the current study is to investigate the potential of BG generation from kitchen waste. It is high time to find out alternative energy resources and sustainable waste management techniques o overcome the present energy crisis and waste pileup. In addition to producing carbon-neutral, another renewable source than natural gas, BG production provides a sustainable way to dispose of natural waste. Discarded food is a big part of municipal waste. Karve .A.D. (2007)

PROPERTIES OF BG

1. Change the volume as a function of temperature and pressure.
2. Caloric value of biogas is 21-26MJ/m3
3. Change water vapor as a function of heat and pressure.

PRINCIPLES FOR BG PRODUCTION
ANAEROBIC DIGESTION

It is also called bio methanization, a natural process that occurs when there is no oxygen. As shown in Fig.1, It involves decomposition of organic matters through various chemical processes through the extraction of energy-rich BG and the nutrient production. (Marchaim, U 1991)

METHODOLOGY

Biogas using KW is one of the feasible concept, which can be implemented in any community, or social units of good number of population, which helps in effective biogas production.
As a part of this initiative, the trial study was executed in our Hostel mess using KW.

From the flowchart Fig.1, Initially, KW is collected and made into small pieces. The crushed KW is transferred into an airtight barrel, which is painted black to keep in warm condition. Secondly, manure is slurried with KW in the ratio 2:1. Biogas (Bg) is collected in an airbag after decomposition in absence of air. The collected gas is used for cooking. (Koniuszewska, 2020).

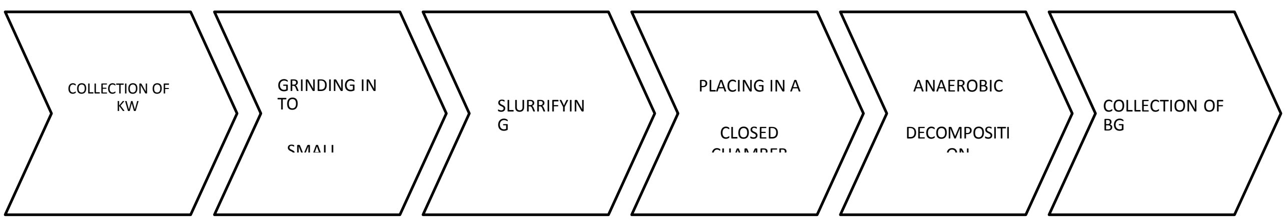

Fig.1 Process Methodology

EXPERIMENTAL PROCEDURE TO MEASURE VFA & ALKALINIY

Production of BG in absence of air helps us economically and provides a notable advantages in environmental point of view. Biogas is collected and stored in an airtight bag, later it is used for cooking after testing all the parameters. The analysis was carried out to check the potential of KW to produce optimum biogas. According to Kapp, A barrel of 2m3 is taken and painted in black to maintain the warm temperature. KW and cow dung is weighed and mixed in the ratio2:1. The homogeneous mixture of KW and BG manure was transferred into to the airtight barrel as shown in Fig 2(a) & (b). BG started evolve after 30days. The produced BG is

transferred to airbag. BG and the slurry from the reactor is analysed and found to be within the limit using standard guidelines issued by Central pollution Control Board, New Delhi. After complete analysis BG is used for cooking and Slurry from the reactor is used for farming. (Mohammed Gedefaw, 2015).As shown in Fig.2 (a) BG Setup was made.

Fig. 2(a) BG setup

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Fig.2 (b) Collection of Kitchen Waste (KW)

Fig.2(c) BG Collector

FACTORS AFFECTING BIOGAS (BG) PRODUCTION

a) Temperature

There is a close relationship between the BG fermentation process and the reaction temperature, BG mostly produces the higher temperatures but the higher temperatures are also not good as it leads to a slowdown in the metabolic process.

b) Retention period

Gas production depends on the volume of the slide in the bio digester (volume of the liquid), usually about two-thirds of the digestive dose. In this study, 30days of retention period was maintained.

c) pH

To foster a BG environment with a neutral pH, the optimum range for BG production is when the pH value of the input digester is between 6 and 7

RESULTS AND DISCUSSIONS

From the fig.1(c), biogas (by absence of air) was collected and stored in an airbag, which the same is used for cooking. The slurry is used as green manure. From the Fig.2 & 3, composition of biogas was calculated and it was found to be within the limit. Arthur W(2000)

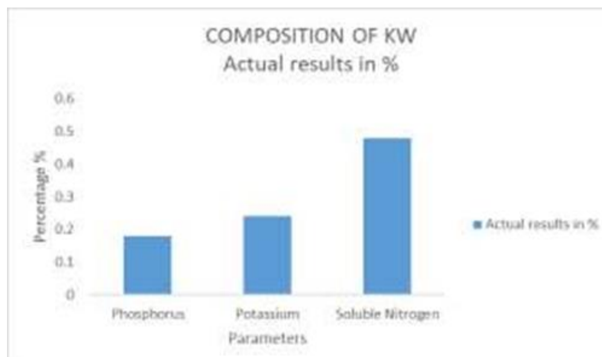

Fig: 3 Composition of kitchen waste

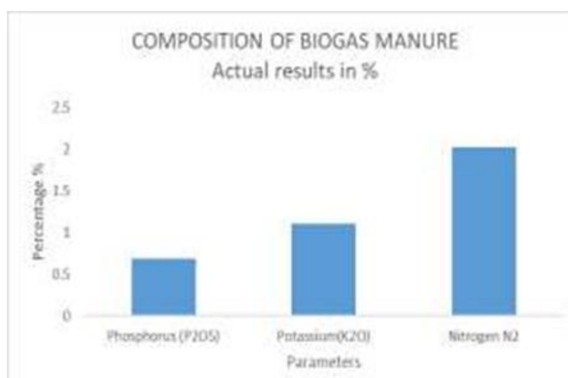

Fig: 4 Composition of BG Manure

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pH:

From fig.4, the p^H increases during the grinding process from 6.58 to 7.63. At this stage, BG production is high. The solid p^H of the digester material is therefore an alkalinity that indicates the buffering capacity of the fermentation system. When the p^H drops, it indicates that the bath system has failed and too much acid is produced normally because methanogenic bacteria have stopped working. Methanogenic bacteria are very sensitive to p^H and do not grow below the value of 6.5. Later, as the digestive process continues, the concentration of NH_4 increases due to the digestion of nitrogen, which can increase the p^H value to more than 8. When the methane production rate is stable, the p^H range remains between 7.2 and 8.2 (FAO / CMS 1996). From Fig.4, P^H is compared for KW and Biogas manure and it is within the optimum normal p^H range.

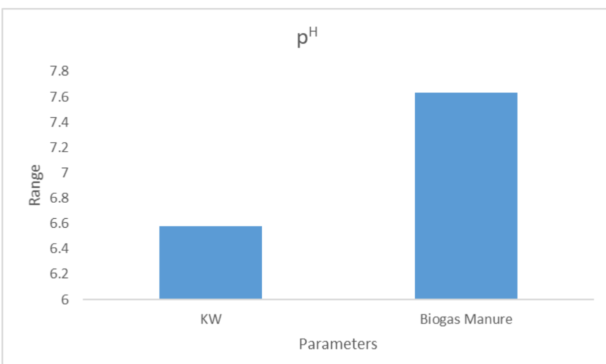

Fig. 5 Comparison of pH

Carbon-Nitrogen Content OF BG MANURE:

Total carbon content in effluent slurry was 2200mg/l. By analysis, C/N ratio was found to be in the ratio 20:1, which was relatively high due to addition of manure in KW and the C/N is the ratio 25:1 for manure, which can be used for the slurry. According to Verma (2002), the maximum C/N ratio in anaerobic digestion is between 15-25

COMPOSITION OF BG:

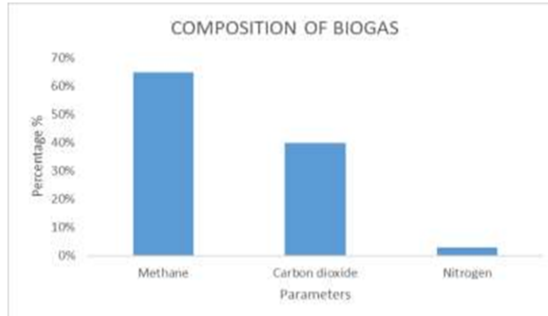

Fig.6 Composition of Biogas (Bg)

As shown in Fig.3, The total amount of gas production is recorded up to 30 days. BG waste products not only serve as another source of energy but also burning BG helps to reduce the production of methane from natural waste which is one of the greenhouse gases. Nevertheless, authentic operational and maintenance function are required for the sustainable production during the lifetime. From Fig4&5 it indicates that, the result was successful production of BG used for the same purpose as cooking. The nutrient content of the BG manure has shown its potential use as a botanical fertilizer. (APHA (2005).

CONCLUSION:

In this trial study, 2m3 of BG plant in our college campus was setup. The results of this trial study revealed that there is great scope and potential for production of BG from decomposition of food waste by anaerobic decomposition in low cost. Our study has proved that there is a major reduction of organic waste and the slurry is effectively used as a manure in farming. Proper collection and segregation of KW will end up in production of effective BG. If this process is implemented on a large scale, it would substantiate fossil fuel and it would be a renewable energy resources. This will certainly contribute to waste reduction and a truly green campus is not available at Zero Waste College.

REFERENCE:

1. Koniuszewska, I., Korzeniewska, E., Harnisz, M., & Czatzkowska, M. (2020). Intensification of biogas production using various technologies: A review. International Journal of Energy Research. doi:10.1002/er.5338

2. Arthur W (2000) Process design of Agricultural digesters. AD-NETT- A Network on Anaerobic digestion of Agro- industrial wastes, p: 8-21. Anaerobic digestion: Making energy and solving modern waste problems edited by Henrik O.
3. Cynthia N, (2010). Biogas Production from Paper Waste and its blend with Cow dung. Advances in Applied Science Research, 1 (2): 1-8.
4. MNES (Ministry of Non-conventional Energy Sources), 2004. Annual report 2003/04. New Delhi: MNES, Government of India
5. Angelidaki I, Ellegaard L, Ahring BK (2003). Applications of the anaerobic digestion process. Adv Biochem Eng Biotechnol. 82:1-33.
6. Ghani WAWAK, Idris A (2009). Preliminary study on biogas production of biogas from municipal solid waste (MSW) leachate. Journal of Engineering Science and Technology, 4(4): 374 – 380.
7. Anonymous 1992 BG Technology in China. Chengdu BG Research Institute of the Ministry of Agriculture
8. Marchaim, U 1991, Biological Wastes. Page 3-5

9. Hessami MA, Christensen S, Gani R (1996). Anaerobic digestion of household organic waste to produce biogas. Renewable Energy, 9(1-4): 954-957.
10. Hurni H (1988). Degradation and conservation of the resources in the Ethiopian highlands. Mountain Research and Development, 8 (2/3): 123- 130.
11. FAO/CMS 1996 A system approach to biogas technology from "Biogas technology: a training manual for extension"page-2-5
12. Mohammed Gedefaw. BG production from cow dung and food waste 2015.Page10-12
13. APHA (2005). Standard Methods for the Examination of Water and waste water. 21st Edition, American Public Health Association, Washington, DC, USA. APHA (2005). Standard Methods for the Examination of Water and waste water. 21st Edition, American Public Health Association, Washington, DC, USA. Page 15-20
14. BG user’s Guide, Vivekananda Kendra-NARDEP, Kanyakumari
15. Itodo IN, Agyo GE, Yusuf P (2007). Performance evaluation of a biogas stove for cooking in Nigeria. Journal of Energy in Southern Africa, 18(3).

ISBN: 978-93-90214-19-8

Restoration of Steam Turbine-Generator Deck RCC Structure Using High Strength Material

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Abstract - Turbine generator or turbo-generator reinforced concrete structures undergo durability distress within the life span due to various reasons. i.e. various failures in turbines due to vibrations, sudden impact due to short circuiting, mechanical failures etc. For continued operation of these structures, repairs/retrofits are framed which involves retro-designing. The problem in each case will be unique and has to be dealt by devising a unique methodology appropriate to the situation encountered.

In this paper, a case study is discussed for the Restoration of concrete structures using modern techniques to reduce the vibrations in the TG Deck foundation with available technological solutions.

Keywords: Turbo-generator, Foundation, Static and Dynamic analysis

INTRODUCTION

Turbine generator or turbo-generator is the power generation machinery operating at a operating speed of more than 3000 rpm. It is the most important rotating machine. The turbo-generator foundation consists of turbine-generator and its rotating parts mounted on a R.C.C table top foundation which consists of deck top, RCC Columns and raft foundation, which is desired to resist the vibrations, static and dynamic load.

Turbo-Generator requires a strong support that can sustain the static & dynamic loads and resulting vibrations.

Turbine-generator foundation is a complex engineering structural component. Different types of turbine foundation are used for different machines depending on their capacity, geometrical sizes and constructional features.

The TG Deck table top foundation should be designed to limit the amplituted of vibration of rotary shaft, Turbine bearings within the permissible range. Excessive amplitude of vibration and eccentricity may cause serious damage in case rotor blades strike the turbine-casing.

Fig. 1: Turbine Assembly

All the equipment of power plant including turbine, generator, governor and other mechanical-electrical instruments are located on top of the deck.

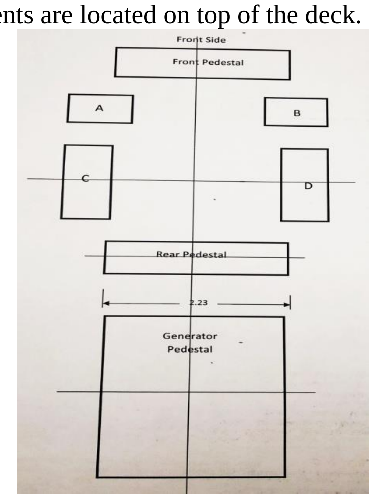

Fig. 2: Frame type foundation

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In the above Fig. 2 the turbine will be placed in the cut-out, after that the turbine gearbox will be placed on the raised pedestal directly in front and generator will be placed on the last pedestal. The machines should be so placed that centre of gravity of all the machines are in one line

These structure was subjected to vibrations of turbine-generators.

In case of undesirable failures during operating conditions, distresses in the structures causes displacements under rotor unbalance excitation.

METHODOLOGY

The methodology includes Non Destructive Testing of the turbo generator foundation where top deck beams and columns are assessed using Instrumentation. The results were verified with standard codes.

Theoretical formulation

2.1 Dynamic Analysis :

During overhauling due to improper alignment and balancing of rotating parts the centre of gravity of may not coinside with centre of rotation of turbine increases the amplitude of vibrations

Results in distortion, loosening or breakage of the turbine shaft blades.

The improper lubrication of rotating parts, improper packing and undesirable heating of moving parts may cause expansion casing increase in amplitude of vibrations.

As per BIS 2974-3 (1992): Code of practice for Foundations for rotary type machines.

The natural frequency criteria of rotary machines: should be less than 20% of the operating machine speed.

$fi < 0.8\ fm$ or $fi > 1.2fin$

where,

fn = fundamental natural frequency of the foundation and fm = operating speed of the machine.

However, it is practicable to keep frequency ratio of 50 %.

Maximum amplitude vibration of the foundation in vertical & horizontal directions should be as per the specification of manufacturers for satisfactory operation of the rotary machine.

2.2 Structural Analysis :

The Primary load acting on the foundations are:

(i) Dead load
(ii) Live load
(iii) Static load
(iv) Static torque load
(v) Loss of blade circulation
(vi) Thermal expansion load
(vii) Dynamic load
(viii) Short circuit load
(ix) Temperature load
(x) Shrinkage load
(xi) Seismic load

2.3 Load combinations considered were:

Normal condition:

DL + LL + SL

Operating condition:

DL + LL + OL + TL

Short circuit condition:

DL + LL + OL + TL

Loss of blade condition:

DL + LL + OL + TLF + LBL

Seismic condition :

DL + OL + TLF + EQL

Dead load includes self-weightof the foundation as well as weight of machines and its auxiliaries.

TEST RESULTS

Structural analysis of a case study of 210 MW TG Deck structure.

3.1 Visual Inspection of Turbo-Generator foundation: During Visual inspections Structural cracks in observed in Beam BC, DE, Co. Beam Junctions BA-AF(Ref. Fig.3,4,5,6)

Fig. 3: Structural Cracks in Beam BC

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Fig. 4: Structural Cracks Beam DE

Fig. 5: Structural Cracks at Col.- Beam BA-AF Junction

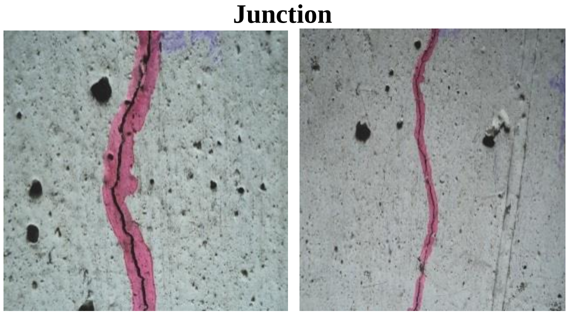

Fig. 6: Structural Cracks at Col.B

3.2 USPV Test:

USPV test was performed to determine the quality of concrete in terms of uniformity, soundness of the concrete.

Test Object :	TG Deck structure
Method :	Direct/Semi-Direct/ Indirect
Instrument :	Tico, Proseq make, Switzerland
Ultrasonic Probe Frquency :	54khz

Turbine casing supporting RCC Pedestals

S.N	Particulars	Path Length mm	Transit Time µs	Velocity m/s
1.	HP rotor Pedestal	1090	1141	960
2.	LP totor Pedestal	565	554.0	1020
3.	IP totor Pedestal	565	257.0	2200

T.G. Deck Beams

S.N	Particulars	Path Length mm	Transit Time µs	Velocity m/s
1.	Beam CD	565	343	1650
2.	Beam BC	721	466	1550
3.	Beam- DE	565	341	1660

T.G. Columns at +5.5m lvl

S.N	Particulars	Path Length mm	Transit Time µs	Velocity m/s
1.	Column A	1200	591	2030
2.	Column B	565	245.0	2310
3.	Column C	781	363	2150
4.	Column D	640	293	2180
5.	Column E	565	253	2230
6.	Column F	1000	381	2630

TG Deck – Generator Slab (Indirect Method)

S.N	Particulars	Transit Time t200	Transit Time t400	Velocity
1.	RCC deck slab	90.7	161.4	2830

The reference Concrete quality grading for different velocities is reproduced from IS: 13311(Part 1)1992 of Table – 2

S.N	**Pulse Velocity (km/sec)**	**Concrete Quality Grading**
1.	Below 3.0	Doubtful
2.	3.1 to 3.5	Medium
3.	3.6 to 4.5	Good
4.	Above 4.5	Excellent

3.2.1 Crack depth measurement by Ultrasonic Pulse Velocity Test(USPV) :

To determine the depth of the cracks beyond or up to reinforcement level.

S.N	Particulars	Transit Time µs t100	Transit Time µs t200	Crack Depth mm
1.	TG. Deck Beam CD	247	466	41
2.	TG. Deck	197.1	339	73

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	Beam BC			
3.	TG. Deck Beam DE	404	607	118
	TG. Deck Columns at 0.0m lvl			
1.	Column A	106.8	134.2	204
2.	Column B	119.2	159.5	167
3.	Column E	139.1	185.5	169
4.	Column F	157.0	211.1	165
5.	Column-Beam Junction BA-AF	163.5	253.0	107

3.3 pH and Potential Test:
To determine the acidic/alkaline condition of concrete

Test Object : TG Deck structure
Method : Titration
Instrument : EI Digital pH meter
Ultrasonic Probe Frquency : 54khz

S.N	Particulars	pH	Potential [mV]	pH	Potential [mV]
		40mm Depth		80mm Depth	
1.	HP rotor Pedestal	11.68	-305	11.83	-315
2.	LP totor Pedestal	11.77	-312	11.97	-324
3.	IP totor Pedestal	11.16	-272	-11.40	-288
4.	Generator raft	11.67	-305	11.63	-302
5.	Deck Beams CD	10.30	-273	10.76	-302
6.	DE	10.97	-233	10.86	-251
7.	BC	10.03	-175	11.44	-257
8.	Column A +5.5m lvl	10.31	-192	11.43	-256
9.	B	9.97	-171	11.39	-254
10.	C	11.41	-256	11.51	-260
11.	D	11.45	-257	11.57	-265
12.	E	11.39	-254	11.50	-261
13.	F	11.63	-268	11.32	-250

The pH value in fresh concrete is in the range of 12 to 13, but due to carbonation effect , the pH value will reduced considerably. pH value below 10, indicates the acidic condition and concrete carbonation which extends up to and beyond the reinforcement level causing corrosion of embedded reinforcement.
BS: 1881 Part 201 1986 gives carbonation depth millimeters as
D = Kt 0.5

Where,
K = Carbonation coefficient in mm /year,
t = time of exposure in years.
The values of K are often 3 or 4 mm/year for low-strength concrete

ANALYSIS OF TEST RESULT
The Principle of Analysis of test results of NDT tests based correlation with respective to the concrete properties for the condition assessment studies of TG deck foundation.
The results of ultrasonic pulse velocity (USPV) are utilized to assess the quality of concrete in terms of soundness categorized as Excellent, Good, Medium and Doubtful. Thereupon, the extent of damages/distortion and the need for re-strengthening are inferred upon.
The pH and Potential test plays a important role in maintaining the desired parameters as per standards. Test results determines appropriate re-strengthening programme is designed.

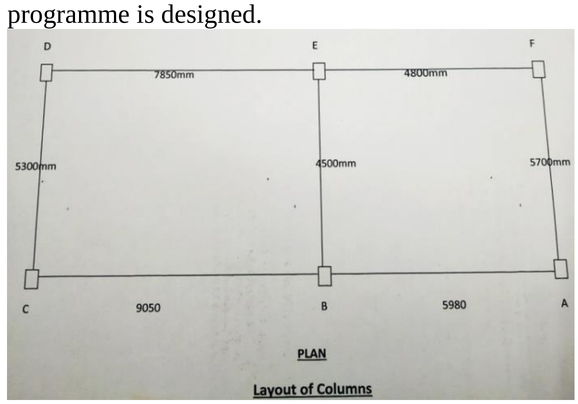

Fig 6 : Top deck beam layout

RECOMMENDATIONS
Rehabilitation/Retrofitting of TG Deck Foundations :
5.1 Treatment to of T.G casing supporting Pedestals

1. Low viscosity Epoxy injection grouting
2. Sealing of cracks & Honeycombed patches with epoxy
3. Epoxy mortar to TG deck pedestal with beam top surface.
4. Fire retarding insulating coating in high temperature zone.

5.2 Treatment to Turbo-Generator Deck beams

1. Low viscosity Epoxy injection grouting
2. Sealing of cracks & Honeycombed patches with epoxy
3. Anti-carbonation epoxy coating

5.3 Treatment to RCC Columns

1. Low viscosity Epoxy injection grouting
2. Sealing of cracks & Honeycombed patches with epoxy
3. Anti-carbonation epoxy coating

CONCLUSIONS

The Turbo-Generator foundation analysed successfully using instrumentation by performing various NDT tests.

The test result indicates strengthening/restoration required for Turbo-Generator foundation.

Retrofitting of structure of Turbo-Generator deck foundation is a challenge and must be determined individually for case to case structure.

ACKNOWLEDGEMENT

1. Madhuraj Naik, S.N. Tande, “Analysis and Steam Turbine Generator structure having R.C.C. Deck”, International Journal, Engineering and Technology, Vol. 5, Issue 4, April2016

2. Technical Report documentation on “NDT of Plant Machine foundations & Buildings” at NTPC, Kawas, Gujarat. Vol. 1 & Vol. 2, Dt. 4.4.2012

3. CPWD Handbook on Repairs and Rehabilitation of RCC Buildings published by DG(Works),CPWD, Nirman Bhawan published in 2002

Vehicle Bridge Interaction Review with Special Emphasis on High Speed Trains

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Abstract - Due to ever increasing demand of public transportation services, India is rapidly moving towards developing high-speed rail network, connecting major cities and urban centres of economic importance. India does not have any railways that can be classified as high-speed rail (HSR) by international standards, i.e. railways with operational speeds exceeding 200 km/h. With the introduction of Vande Bharat express/ Train18 (avg speed 180km/h) and Gatiman Express (avg speed 160km/h) Indian railway is moving towards high-speed train travel. A thorough analytical study needs to be done and validated before designing the bridge structure needed for HSR. This paper aims to review the various train-track-models, VBI models available worldwide which can be useful for this analytical study.

Keywords: VBI, train-track models, moving mass, spring mass models

INTRODUCTION

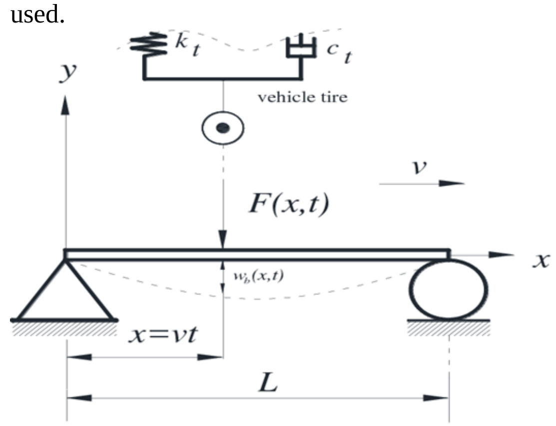
The maximum dynamic response of a bridge induced by moving vehicle is much larger compared to static response of the bridge. Vibration is an important phenomenon in a bridge which may cause due to track irregularities. The early research on vehicle bridge interaction was mainly focussed on dynamic response irregularities. In the early research, the vehicles-bridge interaction system was mainly focused on the analytical solution of the bridge dynamic responses. After that, the researchers made few developments on this problem until the 1960s due to the application of the FEM and computer, which made the analysis of the vehicle bridge interaction possible

The consideration of vehicle bridge interaction is necessary if the vehicle response, in addition to bridge response is desired.[Yang & Yau] In the design of high speed railway bridges, the maximum vertical and lateral accelerations of moving vehicles is used as indicators for evaluating the riding comfort of passengers. From the point of view of structural dynamics, a railway bridge is different from Highway Bridge, in terms of sources of excitation caused by moving vehicles are different for both the cases. Vehicles moving on highway are random in nature. They may have different speed, weight, axle weight. Whereas vehicle moving on railway bridge is a series of connected masses with similar properties.

ANALYTICAL MODELS

2.1 Bridge Model

Many researchers, in past have considered various types of bridge models. As far as beam theory goes, the most common type being [Yang et al.] Euler-Bernoulli beam in which cross sections are perpendicular to the neutral axis prior to bending remain plain and perpendicular to neutral axis. To model an Euler-Bernoulli beam, [Rahaman, Ahmed,2016] an equation for beam can be written containing EI as flexural rigidity,Ɛ as mass of beam per unit length,µ as a damping coefficient can be used.



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2.2 Vehicle models

According to [1] Zhai,Han,Chen (2019) , and work compiled, the moving force model is the simplest and basic model that can be conceived by many researchers which is widely used in early days. However, dynamic response between train and bridge is not considered in this model. These types of models can be used when the weight of vehicle is very small and dynamic behaviour is not of interest. In a comparative study presented by [2] Ye ,Zhang & Guo (2019) on vertical dynamic responses of three types of elevated railway tracks subjected to moving train, was established and solved by periodic theory. The vertical wheel rail forces and dynamic responses of track and viaduct girder are obtained and compared for three different tracks viz. (i) Double block ballast less track (ii) Rubber pad floating slab track (iii) Steel spring floating slab track. It is observed that the rubber-pad and steel-spring floating slab tracks can reduce more than 10% of the wheel/rail force and the reaction force at girder supports, when compared to those of the double-block ballastless track.

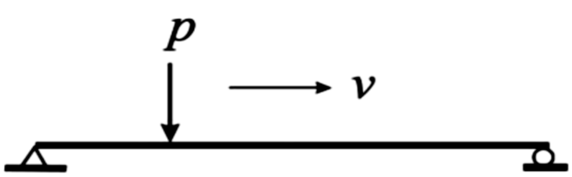

Fig.1 Moving force model [Yang & Wu, 2004., Daria, Sergey, 2018]

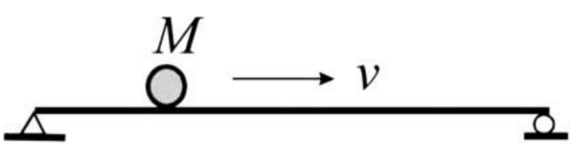

Fig.2 Moving Mass model [Yang & Wu,2004.,Daria, Sergey,2018]

The moving force model can be the simplest and easiest model that can be conceived by considering the train system as moving force [Yang & Wu,2018] neglecting the inertial effect. Moreover if the inertial effect is to be considered, the moving mass model can be utilised by considering the mass and inertia of the running vehicle. But above models cannot give the real idea of a moving vehicle or train on a bridge. It is far more complex phenomenon than it seems. As far as the train load is concerned, several other effects have to be considered. Like the irregular/improper mass, stiffness of connected rail parts, damping. To represent the various dynamic properties of railway freight cars, models of vehicles that contain dozens of degrees of freedom (degrees of freedom) were developed and used by Yang et al. (2016), and co-authors To study the "train-rail-bridge" interaction, a train consisting of a sequence of identical cars was considered by others.

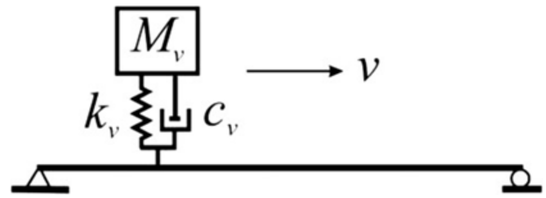

Fig.3 Spring Mass model [Yang & Wu, 2004]

TRAIN-TRACK- BRIDGE INTERACTION MODELS

A standard spring mass system which was extensively developed by work of Yang,Yau & Wu.,2004 is still in force and is very much utilised by many researchers. However the author has also suggested modifying the model by considering [Rahaman, Ahmed,2016] the other parameters like axle forces, may be for single axle or double axel as the case maybe. As far as evolution of train-track-bridge models are concerned, works published by Zhai,Han,Chen,2019 and co-authors can be considered bench mark for taking the research ahead.

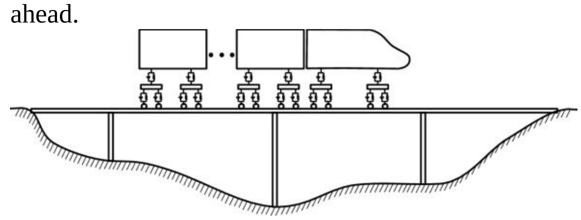

Fig.4. Conceptual train-track-bridge interaction model

Another researchers, [Arvidsson,Karoumi,2014] discusses and put forth the research to model the train-track-bridge interaction. They have compared the already established models. The model adopted by Liu.et.al in the paper , [Arvidsson,Karoumi,2014] called as simplified interaction model (SIM) in which wheel masses and bogie masses are introduced as unsprung and sprung masses. Linear

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spring and dampers represents the primary suspension system and car body mass is represented by constant force.

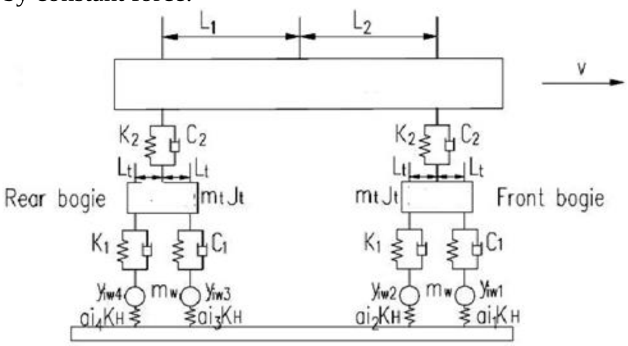

Fig.5. Moving system model [Arvidsson,Karoumi,2014]

A comprehensive comparative study on several existing VBI models are presented by Zou,Deng,Guo and Yin,2015 with the aim to provide the selection of suitable VBI model for study. The vehicles are modelled as (i) moving mass (ii) moving load (iii) spring damper mass model. The spring damper mass model is further classified as (a) 1D, expecting the vertical movement of vehicle axle and vehicle body (b) 2D, considering motion in both the direction in vertical plane (c) 3D, considering movement in all three directions in space.

CONCLUDING REMARKS

(1) [Shi,Ye,Zhang,Guo,2019] The steel spring floating slab track is most effective in reducing dynamic loads at girder support.
(2) [Shi,Ye,Zhang,Guo,2019]The rubber pad floating slab track provides a balanced solution in facing confusion regarding maintenance of track quality and keeping riding comfortability.
(3) There is about 13% to 16% reduction in loads transferred to pier, when compared to double block ballast-less track.
(4) [Zhou,Deng,Guo,Ying,2015] Low order modes dominates the bridge deflections, while strain and acceleration are more sensitive to high order modes of bridge deflections.
(5) [Habib,Chen,2018] The track models doesn't have a very significant impact on the response of the beam bridges with the span ranging between 20m to 30m. However, it can affect the wheel rail contact forces and response of the vehicle significantly. The response of the structure has shown no significant changes for ballast layer continuous and intermittent distribution. The response of the bridge structure is found to be almost the same for a three layer track model and a model without considering the track structure for a frequency range of 0-15 Hz.

FUTURE SCOPE

(1) Improper loading / mass irregularity is can be considered. Since in above models the mass is kept constant, due to the fact that it may add to the complexity of calculations.
(2) Simulated models can be checked by various numerical methods apart from Newmark-beta method for example: fourth order runge –kutta, fifth order runge –kutta.
(3) Steel Spring Floating Slab (SSFS) track is most suitable but reducing driver comfort, Steel Spring Floating Slab track is not suitable for large span as it is increasing the mid-span deflections of girder, beyond permissible limits.

REFERENCES

(1) Wanming Zhai, Zhaoling Han , Zhaowei Chen , Liang Linga and Shengyang Zhu, VEHICLE SYSTEM DYNAMICS,Taylor & Francis,April 2019, Train–track–bridge dynamic interaction: a state-of-the-art review
(2) Muhammad Habib, Zhijun Chen, Vol.5 Issue 2,Feb-20118,IRJET, Train-Track-Bridge-Interaction : A state of the art review
(3) Dariya Provornaya, Sergey Glushkov, MATAEC web of Conferences, TransSiberia 2018,Vehicle Bridge Interaction System
(4) Li Shi, Xiaoquiang Ye, Penfei Zhang, Lin Guo, Hindwai Mathematical Problems in Engineering, Vol.2019, research article on A Comparitive study of vertical Dynamic responses of three types of railway tracks subjected to a moving train
(5) Quiling Zou, Lu deng, Tieding Gou, Xinfeng Yin, International Journal of structural Stability and Dynamics, World scientific Publishing Company, Vol.16, 2016, Comparative study of different numerical Models for Vehicle bridge interaction Analysis

(6) kodai matsuaka, Kiyoyuki, Sogbe, ELSEVIER, Mechanical Systems and Signal Processing, Bayesian Time Frequency analysis of the Vehicle bridge dynamic interaction effect on Simple support resonant railway bridge

(7) Q.Li, Y.L Xu. D.J.Wu and Z.W.Chen, Journal of Vibration and Control, 2010, Computer aided Non-Linear Vehicle Bridge Interaction Analysis

(8) Tahudur Rahaman, Monjur Ahmed, International Journal of Mechanical and Production Engineering, Vol. 4 Issue 5, May 2016, Dynamic Impact Analysis of Vehicle Bridge Interaction System

(9) Zang, Li, Song, Shan,Applied Mechanics & Materials, Vol 2013,Analysis on Vertical Dynamic response of Simply Supported Bridge subjected to simple harmonic loading

(10) Yeong-Bin Yang, Jong-Dar Yau, Journal of Structural Engineering, Nov 1997, Vehicle Bridge Interaction Element for dynamic Analysis

(11) Meng ,Xiao,Zhang, Xu,Chen, Zatar, Hulsey, Special Collection: Analytical Methods for Non- linear Vibration, Non-linear Vibration Analysis of Vehicle –Bridge Interaction for condition monitoring

Green Auditing of Academic Premises: A Tool for Sustainable Campus Life

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Abstract - The Environment where we work is of greatest importance because it is directly linked to life. A healthy environment leads to healthy living. The idea of Green Audit was popularized by many nations across the world after the 1992 Earth Summit in Rio-de-Janeiro. Green Audit is, indeed, an assessment aimed at recognizing environmental policies and operational gaps throughout the management system alongside necessary corrective measures; thereby, serve an equivalent role to financial audits. In the present scenario, many academic premises in India are 1000 or more than 1000 acres. It becomes a necessity to carry out a green audit of such premises for a safer and better environmental condition in an academic premise. Certain Standards need to be maintained following the criteria given by the Ministry of Environment and Forest (MoEF). This paper concentrates on the green audit process in the context of academic premises. The Green Audit is carried out wherein relevant information was obtained, analyzed the findings and correlate with the audit standards. The paper concludes with the identification of the environmental standards and checking for local as well as national perspective. The paper also suggests the identification of existing and future issues that need to be resolved, which will develop a sense of responsibility among the officials and masses in the academic premises.

Keywords: Green audit, Green Cover, Academic Premise, Environment, Standards

INTRODUCTION

The world's rising population, culture, industrialization, and globalization have put considerable strain on the environment. Green auditing started in the early 1970s to review the practice performed within institutions where its actions could threaten the survival of individuals and the environment. It disproves the veracity of claims made by giant corporations about the dangers of environmental contamination on human health. Green Auditing is the modern-day solution to tackle health hazards in the academic premises. It offers a trajectory on how to strengthen the state of the environment, and numerous elements have driven the emergence of Green Audit. The aim of the Green Audit is to preserve the environment of institutes, colleges, academic premises and around them. This is implemented with the aid of processes such as waste treatment, green energy and other of becoming a better environmentally pleasant premise. The Auditing process consists of certain parameters which are needed to be worked upon, water audit, waste disposal audit, energy audit to name a few.

GREEN AUDIT

The Green Auditing process in the academic premises mainly focuses on the following parameters:

A. Energy Audit

The path to a proactive strategy for energy management evaluation is an energy audit. It includes determining all the energy sources in a system and aims to align total energy inputs including its consumption. It calculates energy consumption using data elements. As a consequence, it's a valuable method for identifying and executing a robust energy recovery plan. The strategy to an energy audit has to be efficient and designed to reach the targets, while still taking into account cost considerations. Since the presumption is that the research operations of an audit should be accounted for by the profits it would produce, the deployment of resources can be calculated on a specific instance in a manner that acknowledges the ROI (Return on Investment) [1].

B. Carbon Footprint

The carbon footprint is the cumulative greenhouse gas emissions of an entity, activity, institution, resource or substance measured as carbon dioxide equivalent. General information on primary and secondary origins of Green House Gas emissions is required for the measurement of carbon footprint. Green audit measures the annual tones of CO2 that an academic premise generates, it rather categorizes into primary "carbon generators" such that a comprehensive carbon footprint analysis and evaluation can be done to decide which categories of activity produce carbon footprints and in what concentrations [2].

C. Water Audit

A water audit is a way to calculate all water circulations in a network to assess how it is used, minimise shortages, and increase water sustainability. It discovers the flow path of water and its quantity. Water audit depends on the information available about the irrigation system. More the database available more will be the informativeness of the audit [3]. Water audit help to minimize water fluctuations in a network. Water is also checked for quality by determining its various physical and chemical properties like pH, Turbidity, Hardness etc.

D. Waste Audit

A waste audit is a thorough examination of produced waste that identifies issues, recognizes emerging problems and provides a thorough overview. It is conducted to make sure that all regulations are followed by the institutes, organisations etc. It is essential to compare current policies with the finest recommendations. Waste audit not only helps identify waste reduction opportunities but also create a set of metrics or a benchmark for environmental sustainability [4]. It also works as a risk assessment tool for bits of help identify possible solutions.

E. Green Campus

The pressure to plant trees has never been greater on a global scale. The one trillion trees project of the World Economic Forum has all established clear policy objectives for habitat and land conservation [5]. This attributes to the greenery that is to be maintained in a premise. Trees hold a crucial environmental function as well as supporting better public wellbeing and providing ecological advantages. A single tree provides adequate oxygen for a day's worth of human consumption.

METHODOLOGY

Before performing the audit, the following questions were considered when selecting auditing methods:

- Where can the necessary data be found?
- Is the data comprehensive?
- How will the details be gathered?
- What approach would be used to evaluate the data?
- What is intended to be discovered?

A. Pre-Audit Requisite

This covered strategic concerns such as coordinating the audit, recruiting members of the audit committee, preparing the audit procedure, and collecting relevant statistics of the academic premise.

B. Data Collection

a) Visual Information

• Surveillance – A thorough observation of the academic premise was taken to get a basic idea about the roadmap towards the audit process.

• Professional Opinion – The institute officials and management authority were interviewed about the primary data to be collected and to get suggestions for a better workflow.

• Delphi Survey – A structured communication was arranged with the associated officials accountable for the infrastructural and environmental development of the academic premise.

b) Textual Information

Survey Forms – Detailed survey forms were created covering the five basic parameters of the green audit to be conducted.

i. Survey Form for Energy Audit

• List the ways of energy consumption in the institute

• Is there any energy-saving method employed on the premises? If yes, please specify.

• Record of Electricity bill amount for every month in the past year

• The number of working tube lights, light bulbs, fans, air conditions

• Energy used by each electrical equipment per month (kwh)

• The number of computers is at the institute. Mention use (Hours used/day for how many days in a month)
• The number of inverters installed on the premises. Mentions use (Hours used/day for how many days in a month).
•Electrical equipment used in various labs on the premises. Mention use (Hours used/day for how many days in a month).
• Any renewable energy sources/non-conventional energy sources used in the campus (photovoltaic cells for solar energy, windmill, energy-efficient stoves, etc.) Specify.

ii. Survey Form for Carbon Footprint
• Complete strength of pupil, teaching and non-teaching staff in the academic premises.
• Total Number of vehicles used by the members of the board of the institute.
•The number of cycles used in the institute.
• The number of two-wheelers used and average distance travelled along with fuel used per day.
• The number of four-wheelers used and average distance travelled along with fuel used per day.
• The number of persons using public transportation.
• Usage with every other fossil fuel in the campus (Give the amount of fuel used per day and amount spent).
• Any activity contributing to the emission of carbon dioxide and other gases in the institute

iii. Survey Form for Water Audit
• Sources of water in the institute
• List of water usage in the institute
• The number of water wells on the premises.
• The number of motors used for pumping water from each well.
• Methods for water storage in the institute
• Quantity of water stored in the overhead water tanks.
• Specify any water leakages on the premises.
• Treatment of water used in the laboratories. Whether it gets mixed with groundwater.
• The number of water coolers on the premises. Amount of water used per day.
• Specification of rainwater harvesting units in the college

iv. Survey Form for Waste Audit
• Approximate quantity of waste generated per day on the premises.
• Specification of the waste treatment system on the premises.
• Whether the waste is polluting ground/surface water. Specify.
• Whether the waste is polluting the air of the college. Specify.
• Enlist methods used for composting, recycling, reusing if any.
• Any waste wealth program practiced in the institute.
• Enlist ways of storing waste on-premises.
• Survey Form for Green Campus
• Specify the process of green campus implemented in premises.
• Specify the total garden area on the premises.
• Enlist the type of plants in the garden with approximate numbers of each species.
• Any plantation drives arranged in the institute.
• Description of any medicinal plants in the garden area
• Specify the type of irrigation system used in the garden area.

c) Document Analysis - Information was acquired from databases like enrollment logs, energy and water cost transaction registers, appliance records, laboratory apparatus registers, procurement records, audited accounts, and work registers. Also, Data was collected by verifying institute schedules, its publications, the institute's executive report, and self-assessment papers, among other things.

d) Statistical Review – This was done to check for any previous audit processes or activities carried out in the academic premises to acquire any records.

C. Data Analysis
• Benchmarking – The benchmarking enables academic institutions to easily assess if their amenities are operating at a high level of efficiency, waste, or somewhere in between. This information was used to classify parameters that need more attention in terms of utility, as well as to acknowledge which properties can benefit the most from the audit process.
• Assessment - The results were evaluated following the normal protocol.

RESULTS AND DISCUSSION

Energy Audit:

Following graph shows, the solar units generated from the 150 KW Roof top solar systems for 12 month.

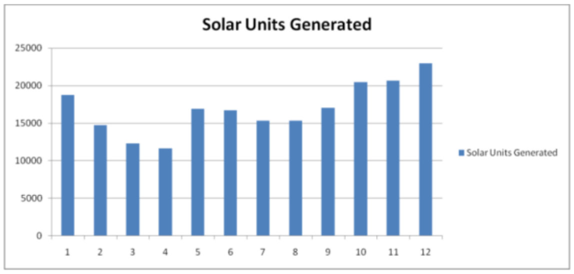

Fig. 1 Solar unit generation

Following graph shows the Energy Consumption for 12 month.

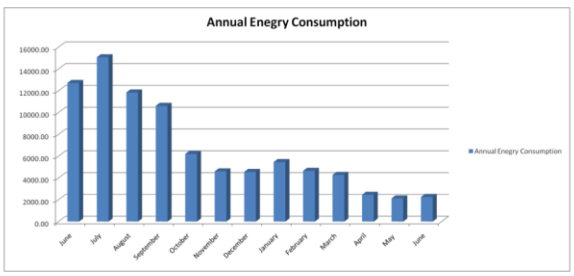

Fig. 2 Electricity consumption

Carbon Footprint:

Table 1Total CO2 Sequestered in the Campus in a Year

CO_2 Sequestration Source	**Amount of CO_2 sequestered (Kg/Year)**
Planted Trees in the Campus	418912
Alternate Electricity Source	174066
Total Carbon Sequestered in the Campus	**592978**

Net Amount of Carbon Emission at KDKCE = 158256 - 592978

= (-) 374722 Kg

= (-) 374.722 Tonnes

Total Carbon Credits:

= 374.722

Net Carbon Pricing Achieved (INR 1635.8705 * 374.722) = INR 6,12,996.00

(As per IHS Markit Global Carbon Index price of one carbon credit is 23.65 $ ~ INR=1635.87)

Water Audit:

Table 2 Overall utilization of water in the College

SN	**Sections**	**Water Use/day (Liters)**
1	Toilets and urinals	15000
2	Hostel	3500
3	Bathrooms	55000
4	Canteen	20000
5	Garden and ground	30000
6	Laboratories	7000
7	Water Coolers	7000
8	Fire Fighting	25000#
9	Leakage*	9600
	Total	**147100**

Dead stock

* Reasons for Leakages are:

• Leak from the Taps

• Over use of Water

• Overflow of water from overhead water tanks

Waste Audit:

Table 3 Total E-Waste Generation

SN	**Name of Department**	**Total E-Waste Generation (Kg)**	**Total E-Waste Reused (Kg)**
1	Electronics & Telecommunication	5	5
2	Computer Science & Engineering	24	17
3	Information Technology	16	11
4	Mechanical Engineering	2	0
5	Civil Engineering	11	0
Total ==➔		**58**	**33**

Green Space Audit:

Routine Green Practices

❖ “No use of Single use Plastics” Drive is undertaken in the campus

 ISBN: 978-93-90214-19-8

❖ "-1 font size" (in printing the documents) Drive is adopted in the campus, which saves the page thus saves the tree.
❖ Digital Circulation of Notices/Invitations is adopted in the campus.
❖ Encouraging Staff & Students to use Public Transportation System or Bicycle for commuting to the college
❖ Use of Recycled cardboard sheets is encouraged amongst the student for academic submission.
❖ "No Spitting" Drive is undertaken in the campus and penalty provision is implemented
❖ Cleanliness Drives are organized on every year
❖ Environment Awareness Programs are undertaken every year in the nearby villages.
❖ Comply to all programs related to the environment envisaged by the statutory bodies
❖ Reuse of Electronic Waste in Display for students for academic purpose

Major Audit Observations
 The installation of Roof-Top Solar Panels are adequate to meet the need of energy in the college
 The carbon sequestration in the campus is excellent.
 The environmental awareness initiatives are substantial.
 Gardens within the college grounds are well kept.
 Use of notice boards and signage is insufficient to minimize over exploitation of natural resources.
 Campus is declared plastic free.
 Rain water harvesting systems, solar power generation, and environmental education initiatives are high.

RECOMMENDATIONS
1. Implement environmentally friendly energy-efficient technologies on the premises.
2. Set up systems to control water, waste, and electricity.
3. Introduction of awareness programs for students in the academic premises to understand the standards of a healthy environment.
4. Introduction of studies related to a sustainable environment in the academic curriculum.
5. Initiating Plantation drives every month on the premises.
6. Formation of committees for regular monitoring of the premises

CONCLUSION
The findings presented in the green auditing study will serve as a roadmap for educating the college community on current environmental policies and the use of resources at the college. A few guidelines are added to minimize waste, overuse, etc. This could lead to a stable future in the form of green campus and, as a result, healthy and sustainable campus life, the atmosphere and community development.
It has been shown frequently that the realistic recommendation, alternatives, and conclusions resulting from audits have been added positive benefits to the audited organization. The green audit report is an effective and useful feedback mechanism to be used when dealing with different partners who need to reassured that the process is going properly and that programmes and protocols are coping with normal improvements and adjustments that arise.

REFERENCES
[1] G. Dall'O', A. Speccher and E. Bruni, "The Green Energy Audit, a new procedure for the sustainable auditing of existing buildings integrated with the LEED Protocols", Sustainable Cities and Society, vol. 3, pp. 54-65, 2012. Available: 10.1016/j.scs.2012.02.001.
[2] S. Verma, M. Ahmad and R. Parwal, "Green Audit – A Boom To Human Civilization", Academia.edu, 2012. [Online]. Available: https://www.academia.edu/5274844/Green_Audit_A_Boom_To_Human_Civilization.
[3] Khedikar, Isha. (2011). WATER AUDIT. INTERNATIONAL JOURNAL OF ADVANCED ENGINEERING SCIENCES AND TECHNOLOGIES. Vol No. 8. 039 - 048.
[4] T. Ramachandra and S. Bachamanda, "Environmental audit of Municipal Solid Waste Management", International Journal of Environmental Technology and Management, vol. 7, no. 34, p. 369, 2007. Available: 10.1504/ijetm.2007.015152.
[5] A. van der Meer Simo, "Livelihood Impacts of Plantation Forests on Farmers in the Greater Mekong Subregion: A Systematic Review of Plantation Forest Models", Forests, vol. 11, no. 11, p. 1162, 2020. Available: 10.3390/f11111162.

Parametical Aspects on Literature Review of PEB Warehouse/CSB using MBS (Metal Building Software) and STAAD. Pro

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Abstract - Pre – Engineered building (PEB), are innovative solutions for construction industry across several sectors. This technology provides the much required design flexibility for steel structures. This is important as no other type of construction provides this level of advantages. In past studies it is validated that the PEB structures are better than conventional steel structure in many respect. This literature survey work is focused on the study of Pre- engineered building and convential building construction technology by standard design techniques (STAAD.Pro) and on MBS (Metal Building Software) in terms of weight which in turn reduces the cost and results is studied. Metal Building Software is a Software Program that does the consummate design, detailing, costing and drafting of steel framed metal buildings. MBS not only helps in accurate design solutions, but also in the efficient use of steel leading to a significant reduction in overall cost. In this research literature survey is carry out to get the design flow work for the both soft wares MBS and STAAD.Pro.

Keywords: Conventional Steel Building, Pre-Engineered Building, STAAD-Pro, Metal building software.

INTRODUCTION

Now a day with increasing urbanization and rapid development in construction activity across the world, steel has created its own identity as the most important building material because of its versatile properties such as durability, tensile strength, and scrap value, recyclable etc. due to which it can withstand external pressures such as earthquakes. Steel also has a high strength to weight ratio which indicates it has high strength per unit mass. Therefore no matter how massive the overall structure is, the steel sections are stronger than other building materials and have a high load carrying capacity and also it can be fabricated as it is flexible and can be molded into any shape without changing its properties and also converted into sheets or other products as per the design.

Pre-engineered buildings (PEB) are steel structures which are fabricated in the factory after designing, transported to site in completely knocked down condition; and all components are assembled and erected at site with nut-bolts or welding, which helps in reducing the time of completion. Pre–engineered generally means any components of a structure which is manufactured prior to its arrival on the construction site. The main concept of the pre-engineered building (PEB) is that the fabrication is to be completed in a controlled environment with the latest techniques, and then erection is carried out.

The main difference in Conventional steel building and PEB is that in PEB structure extra steel is avoided by reducing /tapering the sections as per the required bending moment. This aim of this literature review is to study analysis and design the PEB Warehouse & CSB using MBS (Metal Building Software) and with standard design techniques (STAAD Pro).

LITERATURE REVIEW

Design Concept of Pre Engineered Building by Syed Firoz, Sarath Chandra Kumar B, S. Kanakambara Rao

In this paper the author explains about the various design concepts of PEB structure. In past studies it is noted that practically system the Pre-engineered building system as compared to conventional buildings has great benefits to the single storey buildings as well as profitable alternative, this System represents one central model within multiple developments. PEB structure produces and keeps up continuously multidimensional, information rich perspectives through an undertaking support are right now being executed by different programming packages for design and construction.

For choosing steel to plan a Pre-designed steel structures is to pick a material which offers less expense, high strength, greater solidness, plan adaptability, versatility and recyclability. Steel is the fundamental material that is utilized in the Materials that are utilized for Pre-designed steel building. It discredits from territorial sources. It additionally implies picking dependable modern items which arrive in a colossal scope of shapes and tones; it implies quick site establishment and less energy utilization. Boundlessly recyclable, steel is the material that mirrors the goals of supportable turn of events

A study on design of industrial building-a review by K.Prabin kumar, d.Sunny prakash

This paper shows the complete design and code book procedure for industrial building. The results shown similarities in the design of the structure. The deflection values while designing were reviewed to be less than the calculated allowable deflection. Thus, the structure is safe against deflection.

Performance of Metal Buildings in High Winds by Dale C. Perry, Herbert S. Saffir, James R. McDonald

In this paper the performance of Metal Building is detected in high winds areas to discuss and analysis the changes required in design of the building that are found i.e heavy purlins and girts are required, base plates govern heavy load due to high wind also the cost and time requirement is found out for the designed building.

Comparative Study of Analysis and Design of Pre-Engineered- Buildings and Conventional Frames by Aijaz Ahmad Zende, Prof. A. V. Kulkarni, Aslam Hutagi

This paper introduces and study of steel structure for both PEB (Pre Engineered Building) and CSB (Conventional Steel Buildings). In which both the structures are analyzed using STAAD-Pro resulting more economy in secondary and wastage of materials in PEB as in comparison with the CSB in ratio of 1:1.5

Case Study On Pre Engineered Building by Sarath Chandra Kumar B, S.Kanakambara

In this research the complete concept of design flow and PEB building is studied and all the details related to that are described The pre-engineered steel building system construction has great advantages to the single storey buildings, practical and efficient alternative to conventional buildings, the System representing one central model within multiple disciplines.

Pre-Engineered Building Design of an Industrial Warehouse by Anisha Goswami, Dr. Tushar Shende

In this paper the author presents the design of an Industrial Warehouse structure located at Nagpur. The structure is proposed as a Pre-Engineered Building of having width 30 meters, 8 no of bays each of 7.5 meters in length and an eave having height of 6 meters. In this work, 30 meter wide PEB frame is taken into consideration and the design is worked out by accounting wind load as the critical load for the structure. Conventional steel building frame is also designed for the same model considering an economical roof truss configuration. Both the designs are then compared to find out the technical outputs. The designs method adopted is in accordance with the Indian Standards codes and by the help of the structural analysis and design software STAAD pro. Based on the analysis the results in the present work, for the selected structure weight of steel can be reduced up to 27%, which is due to lesser dead load which in turn offers higher resistance to dynamic forces.

ISBN: 978-93-90214-19-8

Pre-Engineered Building Design of an Industrial Warehouse by C. M. Meera

In this paper the author's presents design idea of single story pre-Engineered industrial stockroom Building design. The principle point of this work is to contemplate relative examination of design of Conventional steel Building (CSB) and Pre-Engineering Buildings (PEB).Conventional Steel Building is a traditional idea wherein additional time required, quality and normal erection factor to change that issues Pre-Engineering concept is developed and the equivalent is acquainted with the Indian market in mid-1990's.The idea of PEB is totally adaptable when contrasted with ordinary steel building due to its quality, construction, light weight and inexpensive construction..

To achieve the main aim of this study a typical frame of commercial warehouse shed is meant with both CSB and PEB concept and analyzed the designed structure with the assistance of the structural analysis and style software STAAD Pro. The results found out after analysis are as follows

S.no	Technical Features	Pre-engineered building	Conventional steel building (Portal Frame)	Conventional steel building (Truss)
1.	Support reaction [Fx] [KN]	195.855	277.218	48.756
2.	Support reaction [Fy] [KN]	193.548	231.218	171.156
3.	Support reaction [Mz] [KN]	404.019	947.317	148.981
4.	Displacement [MM]	278.707	81.99	44.861
5.	Axial Force [KN]	212.628	294.43	557.477
6.	Shear Force [KN]	195.855	277.516	48.756
7.	Bending moment [KNm]	771.235	947.317	148.981
8.	Steel Take off [KN]	511.733	940.882	704.951

Concept of Metal Building Software by M.Mohana, T.S.Mukesh, S.Vettri Indhujha

The above paper studies the working of Metal building software in reference with the existing structure which is designed from the different software. In this paper the detailed study is done on the working of the MBS with its design flows, its simple and convenient ability to design the metal buildings which all the required details in minimal time requirement and with the cost conservation when it comes to comparison with the standard design techniques,

Comparison of Conventional Steel structure and PEB structure

S.no	Technical Feature	Conventional Steel Building	Pre Engineered Building
1.	Weight	Conventional steel section are available in standard size, hence profile section is not possible as per bending moment requirement. Therefore, weight cannot be reduced	On average 25% steel is saved in PEB building due to use of tapered section
2.	Erection time	As the standard details are not available due to which time of erection increases	All the standard details of components/ equipment which required in PEB structure are known. Hence the same are stored in bulk quantity which ultimately helps in reducing the erection time
3.	Foundation	Heavy weight of foundation due to heavy weight of structure	Light weight of foundation due to lesser weight of structure

4.	Design	Each conventional steel structure is designed from scratch by the Consultant, with fewer design aids available to the Engineer. Maximum engineering required on every project. Generalized computer analysis software quires substantial input and design alterations. Drafting is manual or only partially automated. Important time and cost on consulting services are committed to design and drafting, as well as coordination and review.	Brisk and proficient since normalization of PEB has essentially diminished design time. Basic designs are used over and over. Specialized software based analysis and design programs decreases design time and optimize material required. Drafting is also computerized with minimal manual drawings. Design, detail drawings and erection drawings are provided complimentary by the manufacturer. Approval drawings may be prepared within 1 week to 3 weeks. Consultant in-house design and drafting time is reduced, which allows more time for coordination and review. Since most PEBs are pin-based, the expense is decreased because of more modest components at the base with more modest base plates and establishments
5.	Performance	Components are designed in general for possible use in many alternative configurations. Designing and drafting errors are possible in gathering different components into unique buildings. Each building configuration is extraordinary, so expectation of how components will perform together is unsure. Materials which have performed well in some climates may not in other environments	All components have been specified and designed specifically to act together as a system, for maximum efficiency, accurate fit and performance in the specified site conditions. Consistent design upgrades over the long run take into account trustworthy forecast of execution
6.	Overall Price	High price per square meter.	Price per square meter could also be the maximum amount as 40% less than conventional steel

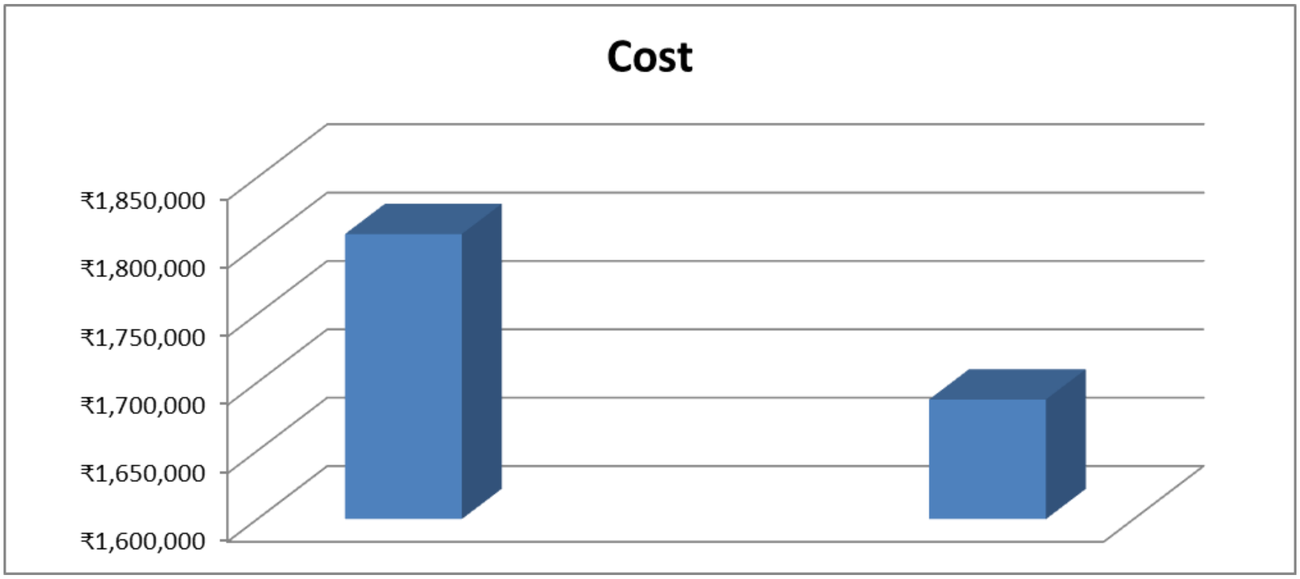
RESULTS AND DISCUSSION

Based on the literature studies, we have found out the following outcome with use software and they are mentioned below

In the present study, it has been seen that when it comes to designing of the PEB warehouse there are various parameters and technical specification on which the PEB structures are much beneficial than CSB.

As it can be clearly seen that, weight of the PEB structure is 25% (approx.) lesser than the CSB Structure due to which there is saving of material. Thus cost of structure reduced.

ISBN: 978-93-90214-19-8



Cost Comparison Graph for Primary of PEB and CSB
Source – Research paper (b)

CONCLUSION

In this present work the following findings are obtained
In the current study it is found the PEB structures are way more cost conservative than CSB structures.
Also when it comes to the design of PEB Warehouse, with the help of Metal building software the weight of the PEB ware house is reduced as in comparison to the standard design techniques.
The reduced weight is the dead load of the structure due to which weight foundation will also be reduced and also due to lesser dead load the structure will offer higher resistance against the seismic forces.

REFERENCES

1] Dale C. Perry, Herbert S. Saffir, James R. McDonald, "Performance of Metal Buildings in High Winds", Journal of Wind Engineering and Industrial Aerodynamics, 36 (1990) 985-999 985, Elsevier Science Publishers.
2] Syed Firoz, Sarath Chandra Kumar B, S. Kanakambara Rao," Design Concept of Pre Engineered Building", IJERA Vol. 2, Issue 2,Mar-Apr 2012, pp.267-272
3]M.M. Banerjee, A.N. Malik, "Application of Building Information Modeling in Construction Management with Clash Detection" , International Journal of Latest Trends in Engineering and Technology March-2011, Jeremy Newton, "Clash Detection in construction industry" , Currie and Brown May-2011.
4] Luger and Stubblefield, "Application of BIM's in Construction Management", International Journals of Engineering Science Invention. Vol.08 JULY 2019
5] Int. Journal of Engineering Research and Applications www.ijera.comISSN : 2248-9622, Vol. 5, Issue 3, (Part -2) March 2015,pp.05-09
6] International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 05 | May -2017
7] Chavan, V., Nimbalkar, V.andJaiswal, A. (2014). "Economic evaluation of open and hollow structural sections in industrial trusses", International Journal of Innovative Research in Science, Engineering andTechnology, ISSN: 2319-8753 Vol. 3, issue 2.
8] K.Prabin kumar, d.Sunny prakash, "A study on design of industrial building-a review", U.G. Scholar, department of civil engineering, saveetha school of engineering, saveetha university, India.
9] Aijaz Ahmad Zende, Prof. A. V. Kulkarni, Aslam Hutagi, "Comparative Study of Analysis and Design of Pre-Engineered- Buildings and Conventional Frames", OSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 5, Issue 1 (Jan. - Feb. 2013), PP 32-43

Design and Analysis of Lift Irrigation System: A Literature Review

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Abstract - Lift irrigation is one of the important irrigation methods in areas that have irregular precipitation. This type of method make irrigation possible at higher level and at isolated small areas. The other benefit of lift irrigation is the minimal land acquisition problem and low water losses. In recent years, lift irrigation has become widely used method for irrigation of land. Lift irrigation shows the major benefit of saving water and also improving yields and crop quality. However, it also delivers many other economic and social benefits to the society. This paper makes an effort to review literature on design and analysis of lift irrigation system. In this paper, the focus is on various case studies on lift irrigation system. An attempt has been made to provide comprehensive overview of lift irrigation systems, the data needed for planning of such a system, the procedure of collecting the required data, and the design process of a lift irrigation system.

Keywords: Irrigation, Lift Irrigation scheme, Perennial sources, Distribution system, Solar lift Irrigation.

INTRODUCTION

Irrigation system is needed in the country like India because it's an agricultural country where growing population coupled with food security has put extra pressure on water resources. Country has now reached a situation where the demand of water from various sector of economy is rapidly increasing while the supply of fresh water is constant. The lift irrigation is method of irrigation in which the water is not flows under gravity but it is lifted by means of pumps and other mechanical devices. The purpose of Lift Irrigation is to carry water to the delivery chamber from water source and distribute the water through pipeline to nearby fields within its area in the flood plains of the river. Traditionally, construction of dams and canals has helped in increasing the irrigated area lying at lower level than the dam level tremendously, but scarcity of water remained the problem for higher level areas. So as to bring higher level area under Lift Irrigation Scheme are taken up. About 8% of Maharashtra irrigation is occupied by lift irrigation. In lift irrigation scheme the water is supplied to highly elevated area where the water not flows under gravity but it is lifted from the perennial water source located at lower area by means of pumping criteria. Land acquisition problem in lift irrigation system is less, water losses are low. In lift irrigation scheme the main requirement is that the water source from where the water is to be lifted should be a perennial source, so that water is available throughout the year with the constant flow. For this construction of dam, reservoir or a tank should be done. Water can be made available through Dams, K.T. Weir, River canal etc. Lift irrigation scheme requires mainly lifting medium to lift water to the desired location, lifting medium (i.e. pumps) are required. Depending upon the Duty point head, discharge different types of pumps are selected. In lift irrigation scheme the pumping system and rising pipe system is required in which the rising main pipe system may be consist of concrete, steel or any other suitable material. Lift irrigation schemes mainly consist of Civil, Electrical and Mechanical works. Which include Intake well, Pump set, Jack-well, pump house, Electrical accessories and fittings, Sump well, Rising Main, Sub-Mains, Transformer and power connection, Electric Pumps, pump house, Protective devices, Intake pipes and Distribution System. Components of a Lift Irrigation System Includes the intake structure is built at the entry to the irrigation system to direct water from the original source of supply (lake, river, reservoir, etc.) into the irrigation system. Water from intake well carried to the jack well or sump well through an intake pipe, the water is first collected in a structure called jack well and then lifted from there. Jack well is designed in such a way that it should be able to carry design quantity of water which is to be lifted. Pump house is made which lift water from jack well. Firstly water is lifted from jack well to sump well which is then distributed to that command area. Rising main plays an important role for lifting the water from the jack well to the sump well. Sub-Mains serve this purpose. Electric pumps plays an important role in lift irrigation system. In lift irrigation scheme in pumping the high capacity pump are required which having the capacity in range of 30HP to 500HP are used to cater the demand of

Fig-1 : Kaleshwaram Lift Irrigation Project

required area. At location where the electricity is not available at that time solar pumps can be used.
Kaleshwaram lift irrigation project shown in fig. 1 is an Indian lift scheme to become the world's biggest in terms of irrigation capacities. Similarly Gose-Khurd Irrigation Project is one of the major irrigation projects in Maharashtra in the Bhandara district on the river Wainganga. The Gosekhurd Irrigation Project is one of the biggest irrigation project in Vidarbha Maharashtra situated in bhadara district declared as National Irrigation Project by Government of India. In India numbers of irrigation and lift irrigation project were done some of them are also in progress. Construction of Kaleshwaram Lift Irrigation Project which is world's largest irrigation project serves the drinking, irrigation and industrial purposes, located in Telangana. Execution of Khalwa Micro Lift Irrigation Scheme in Madhya Pradesh and also construction of Jawar Micro Lift Irrigation Scheme Project in Madhya Pradesh. A lift irrigation project at Kherva to Visnagar is plan to set up by Narmada Water Resources. Sitarama Lift Irrigation Project Phase-I., Dehani Lift Irrigation Scheme, Punasa Lift Irrigation Scheme, Purandar Lift Irrigation scheme.

Table-1 : Major Irrigation Projects of India

Name	River	State	CCA, ha	Year of completion
Bhakra Nangal Project	Sutlej	Punjab and Himachal Pradesh	40,00,000	1963
Beas Project	Beas River	Punjab, Haryana and Rajasthan	21,00,000	1974
Indira Gandhi Canal	Harike (Satlej and Beas)	Punjab	5, 28,000	1965
Koshi Project	Kosi River	Bihar and Nepal	8.48,000	1954
Hirakund Project	Mahanadi	Orisa	10,00,000	1957
Tungabhadra project	Tungbhadra - Krishna	AP-Karnataka	5,74,000	1953
Nagarjuna Sagar Project	Krishna	AP	13,13,000	1960
Chambal Project	Chambal	Rajasthan and Madhya Pradesh	5,15,000	1960
Damodar valley project	Damodar	Jharkhand, West Bengal	8,23,700	1948
Gandak project	Gandak	Bihar-UP	16,51,700	1970
Kakrapar project	Tapti	Gujarat	1,51,180	1954
Koyna Project	Koyna- krishna	Maharashtra		1964
Malprabha project	Malprabha	Karnataka	2,18,191	1972
Mayurakshi Project	Mayurakshi	West Bengal	2,40,000	1956
Kangsabati project	Kangsabati and Kumari river	West Bengal	3,48,477	1956

BACKGROUND STUDY

Development of Lift irrigation schemes has happened in last five decades in India causing into deep and far reaching impact on the agricultural economy of the country. In India, National Bank for Agriculture and Rural Development (NABARD) has financed 1401 lift irrigation schemes. In India there are 45 Lift Irrigation Schemes in Ganga river basin that are spread in four states i.e 27 project in Uttar Pradesh, 9 project in Bihar, 6 project in Haryana and 3 project in Madhya Pradesh.. Out of 19 sub-basins of Ganga, about 10 sub-basin have lift irrigation schemes. In the Yamuna sub- basin there are 7 lift irrigation schemes out of which 6 are in Uttar Pradesh and 1 in Madhya Pradesh. The 7 schemes are named Augasi, Kishanpur, Yamuna, Chillimal, Umarahat and Jarauli Lift scheme in Uttar Pradesh and Renhat Lift scheme in Madhya Pradesh. One of the major irrigation projects in Maharashtra is The Gosekhurd Irrigation Project in the Bhandara district on the river Wainganga. It is one of the largest lift irrigation project in the Vidarbha region and has been declared as a National Irrigation Project by the Government of India. This project involve lifting stations at Akot, Ambhora, Mokhabardi, Nerla and Tekepar. The Mokhabardi Lift Irrigation Project is situated near the Kinhala village in Nagpur District is one of the lifting station of Gosekhurd Lift Irrigation Project. At this station, water is lifted from the reservoir by large pumps and is then distributed through gravity-fed canals in different directions to irrigate agricultural land and provide drinking water to various villages.

LITERATURE REVIEW

Project Report on Sita Rama Lift Irrigation (2006):- Concludes that, this scheme is to meet the requirement of water for both domestic and industrial growth due to creation of new districts for that Sita Rama Lift Irrigation Scheme is being devise to irrigate the Khammam, Bhadradri Kothagudem and Mahabubabad Districts. To create an Ayacut of about 6.74 lakhs acres in Khammam, Bhadradri Kothagudem and Mahabubabad Districts, by the diversion of 70 TMC of Godavari water by lifting to the lands on higher Contour.

Executive Summary (2009): - Ashti Lift Irrigation Scheme, Tal: Ashti, District: Beed Founds that implementation of the project, agricultural production will increase in the command area of this project, thus improving the financial conditions of the people living in the area. Due to supply of irrigation water, drinking water, the economy of the area and quality of life in the study area will improve. By irrigate land in Ashti taluka in Beed district by lifted water from Ujani reservoir and to provide stable supply of Irrigation water for crops and resulting in increasing agriculture yield.

A. M. Zende (10 April 2012):- Investigated the Takari lift irrigation scheme main canal. Total main canal length is 144 kilometers. The secondary canals are not in good conditions to pass the water through them. They have conclude that the considerable increase in the output per unit of land and per unit of water after the impact of management turnover process.

B. Rao (2012):- Studied effect on crop production and the water utilization pattern under Amarachinta Lift Irrigations Scheme in Mahaboobnagar district of Andhra Pradesh. By the assessment of dynamics of water resources utilization and its efficiencies in the selected lift irrigation scheme. He had conclude that daily water release from the lift irrigation scheme was more during the post monsoon season as compare to that of monsoon season due to higher value of potential evapotranspiration.

H.P. Singh (26 August, 2013):- Study to assess the performance of irrigation water management of lift irrigation scheme Sirsa Manjholi in Solan area of Shivalik Himalayas. If the no permanent diversion headwork will done then it will not possible that the construction of lift irrigation scheme will not induced any change in cropping area and cropping pattern of command area and fulfilled the irrigation requirement for that to overcome this the permanent diversion of head from the stream should be done.

An Article on Kaleshwaram Lift Irrigation Scheme project (2016):- Found that the world's biggest lift irrigation scheme "Kaleshwaram lift irrigation project" is to harness the flood waters of the Godavari River so that Telangana can be made drought-proof. The completion of this project on the Godavari River will solve the issue of supplying the water all across the Telangana to farmers for the irrigation and ultimately lead to refill thousands of tanks and providing water to the number of industries and also supplying drinking water for the Hyderabad. By creating the series of storage tank and networks of pipeline. It will be the historic landmark for the Telangana.

P.K. Viswanathan (December 2016):- Undertakes the critical review on the performance of major/ medium and minor irrigation systems in Kerala, which redesign the irrigation system such that system serves as a multiple use system. In terms of irrigation provision flood management drinking water security for human and animals and provisions of economic and environmental services. Which only fulfill by the lift irrigation system.

S. Shiyekar (Jan -2017):- Conclude that the reason facing the problem of water scarcity and the lack of very low precipitation can be overcome by installing the lift irrigation scheme and make the area again agricultural and cultivable.

P. P. Paudel (2019):- Study the solar lift irrigation project in Krishnapur-05, Gulariya, Kanchanpur for irrigating agriculture land. They have studied that the lift irrigation project lead the country towards the sustainable development of society.

CONCLUSION

Lift irrigation is used all over India not only for irrigation but also for the industrial and sustainable development of society and also for the employment, electric power generation. The water losses are minimum and less manpower is used. Lift irrigation is a scheme which had make possible to irrigate the area which located at high altitude where the natural gravity flow is not possible. From the review of all literature, it can be concluded that use of lift irrigation system is important and has multiple benefits. It can solves the problems of water scarcity, lack of low precipitation, depletion of water table and drought prone region environment by making water available in the season when it is required. In design of lift irrigation scheme complex pumping and operational equipment are required along with constant water supply, which ultimately raise the cost of supply to the field.

REFERENCES

[1] WAPCOS LIMITED (International Consultant in water Resources Power and Infrastructure, Development), Detailed Project Report on "SITA RAMA LIFT IRRIGATION PROJECT, PHASE-I", Gov. of Telangana (2006).

[2] Executive summary of "ASHTI LIFT IRRIGATION SCHEME, TAL: ASHTI, DISTRICT: BEED", (2009).

[3] Abhijit M. Zende, R. Nagrajan and Kamlkishor. R. Atal, "Performance Assessment of Temporal Irrigation in Western Maharashtra, India: Takari Lift Irrigation Scheme Case Study", ResearchGate Publication (10 April 2012).

[4] Bhaskara Rao , K.V.Rao, R.K.Sahu and Atul R. Dange "Crop production and water utilisation under lift irrigation scheme in Andhra Pradesh", Indian Journal of Soil Conservation (2012).

[5] H.P. Singh, M.R. Sharma, Quamrul Hassan and Naved Ahsan, "Performance Evaluation of Irrigation Projects - A Case Study of Lift Irrigation Scheme Sirsa Manjholi in Solan area of Shivalik Himalayas" (26 August, 2013).

[6] Article on "Dr. B.R. Ambedkar Pranahita-Chevella Sujala Sravanthi project" (2016) https://www.google.com/url?sa=t&source=web&rct=j& url=http://www.irrigation.telangana.gov.in/img/projects pdf/kaleshwaram.pdf&ved=2ahUKEwjLqc3s1bbsAhVo zjgGHSo3AhwQFjAEegQIAhAB&usg=AOvVaw0cN- 39SEm9jQWP2wtEsGbJ

[7] P.K. Viswanathan, "The case Design of Lift Irrigation Schemes as Multiple-Use Systems: Reengineering the Irrigation Systems of Kerala", ResearchGate (July- December 2016).

[8] Seema Shiyekar and Nandkumar K Patil, "Design of Angar Lift Irrigation System- A Case Study", published by International Research Journal of Engineering and Technology (IRJET), (Jan -2017).

[9] P. P. Paudel RCT Engineering Workshop, "SOLAR LIFT IRRIGATION PROJECT IN DEVDAS KRISHI FARM", Krishnapur-5, Gulariya, Kanchanpur, Nepal (2019).

Morphometric Analysis of Noa-Dihing Watershed, Arunachal Pradesh

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Abstract - The Remote Sensing and Geographic Information System (GIS) has become very powerful and influential tools for comprehensive landform analysis, water resource planning and management. Noa-Dihing river basin, which is located at Changlang district of Arunachal Pradesh, is designated as the research area. To determine the morphometric parameters and drainage properties of the basin, Remote Sensing and GIS data are used. The morphometric analysis of Noa-Dihing river basin is carried out by GIS based techniques and the parameters are classified under linear, relief, and aerial aspects. For ordering of channel networks, Strahler's stream ordering techniques are followed. From the computed results,Noa-Dihing river basin is of 6thorder stream and drainage is dendritic in nature.

Keywords: Remote Sensing, Geographic Information System, Morphometric Parameters, Dendritic

INTRODUCTION

Literal meaning of morphomety is the measurement of external form and analysis means detailed evaluation. Therefore, in geomorphology, morphometric analysis means detail evaluation of landforms through mathematical measurement. To understand the various physical properties and erosional features of soil, drainage morphometry is very important [1].

Generally river basins are taken as the major units of morphometric analysis. The area of land in which surface water enters from any direction and then converges to a single point before exiting is known as a river basin. The river basins are delineated by ridge lines which are called water divides. The principal advantage of GIS based morphometric analysis is to understand the basic characteristics of river basin on the basis of geometrical and mechanical aspects [2]. The various morphometric parameters are divided under three heads; namely linear, areal and relief parameters of the drainage networks. The overall assessment of a drainage system can be obtained from the morphometric analysis of river basin and it is a very significant feature for the characterization of basins [3].

Remote Sensing offers a very useful basis in preparing the different thematic layers in morphometric analysis. Digital elevation data is used to create elevation models for any terrain. The developed DEM is used to build the stream network and additional useful layers to evaluate the basin and evaluate the different parameters of the basin, to assess, interpret and study spatial details, using GIS-based techniques [4]. The different processes involved in the assessment by GIS techniques of the different morphometric parameters of the Noa-Dihing river basin of Arunachal Pradesh are defined in the current research paper.

DESCRIPTION OF STUDY AREA

Noa-Dihing river basin which is located at Arunachal Pradesh is the research area. It is also called as Diyum in its upper most part by the Singphos. It is a very important tributary of the Brahmaputra river system and it contributes about 2.41% of the annual discharge of river Brahmaputra at Pandu. After traversing in a northwesterly direction from its origin, it flows generally in westerly direction beyond the confluence of Namdapha river, the largest tributary, through the hilly terrains of Changlang District upto Miao. Thereafter, it bifurcates into two branches, of which one is known as Noa-Dihing, which flows generally in northern direction and the other known as Kahikee / Meganton which flows generally in south western direction.

The total length of Noa-Dihing river from its starting point to its joining point with Lohit river is 157 km.

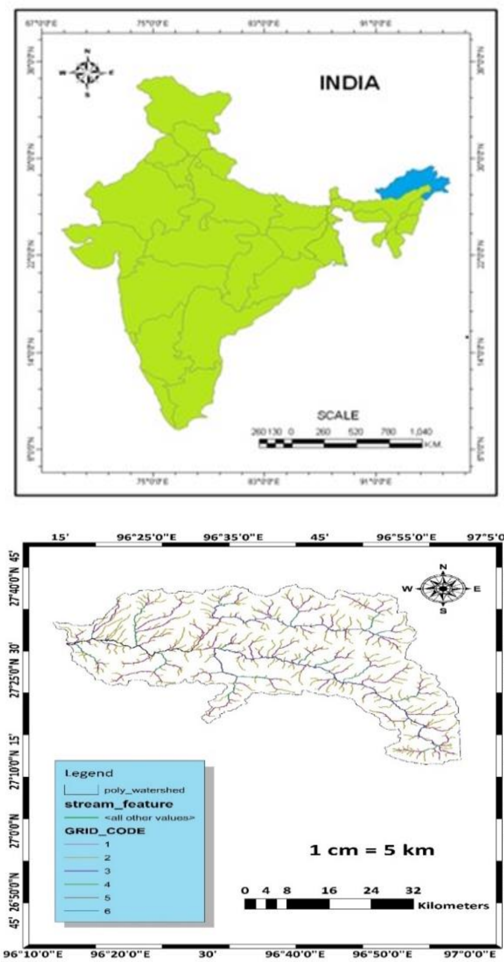

Fig.1 Location Map of the selected Study Area

DATA AND METHODOLOGY

The fore most goals of morphometric analysis are to identify diverse drainage features and to assess the overall basin [5]. Since the research area falls under restricted regions of Assam and Arunachal Pradesh, no toposheets are available. Morphometric analysis is done in GIS platform using SRTM Digital Elevation Model (DEM) data of 90 m spatial resolution. SRTM DEM satellite imagery data is obtained from United States Geological Survey (USGS). The elevations of various points of a particular region are indicated by DEM data (Fig. 2) [6]. USGS data were analyzed using ESRI ArcGIS 10.1 software with Spatial Analyst tool. Drainage networks are delineated with DEM of SRTM using Arc map 10.1. Morphometric parameters which are evaluated for the Noa-Dihing basin include basic, derived and shape parameters. The various steps involved in the analysis are depicted as a flow chart as shown in Fig.3.

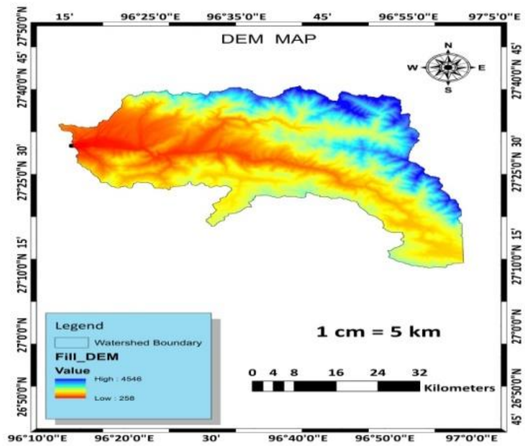

Fig. 2 SRTM DEM (90 m spatial resolution) of the study area

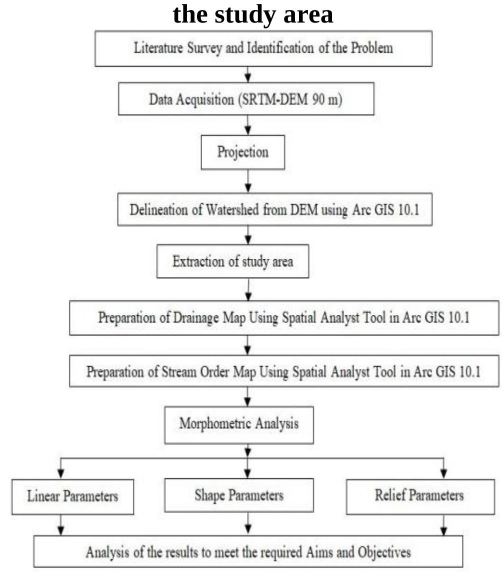

Fig. 3 Flow Chart implemented in the present study

RESULTS AND DISCUSSION

Area (A), perimeter (P), number of streams (Nu) and total length of streams (L) are the basic morphometric parameters and areachieved from Arc GIS 10.1 software and other significant parameters are evaluated by means of various mathematical formulae, given in Table 2.

4.1 Analysis of Drainage Network

The study results obtained by analysing the stream order map as shown in Fig.4 with ESRI Arc GIS 10.1 software are listed in Table 1.

4.1.1 Stream Order (U)

Identification of stream orders is the starting step in drainage analysis. Streams are ranked following the system given by Strahler. Table 1 shows the stream order, number of streams and total length of streams with different stream orders for Noa-Dihing basin and it is observed that it is a 6th order drainage basin.

Table 1: Stream Order and No. of Streams

Stream order	**No. of Streams, N_u**	**Length of Streams (km), L_u**
1	362	743.6
2	74	353.4
3	21	120.2
4	2	122.5
5	1	17.76
6	1	32.19
	Total = 461	**Total = 1389.65 km**

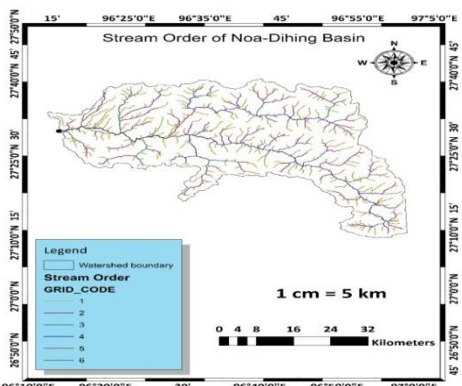

Fig. 4 Stream order map of Noa-Dihing basin

4.1.2 Stream Number (N_u)

It is the total number of stream segments with different stream orders. N_u goes on decreasing with the increase in stream order. Table 1 shows that stream order 1 has the maximum number of streams i.e. 362 and Stream order 6 has the minimum number of streams i.e. 1.

4.1.3 Basin Length (L_b)

The prolonged length of the basin, from the watershed to the point of convergence. It is given by $L_b = 1.312\,9\ A^{0.568}$ where A is the total area of the basin **[7].**

4.1.4 Stream Length (Lu)

Stream lengths of various orders are measuredby Arc GIS 10.1 software. Total stream length of various orders is shown in Table 1.

4.2 Mean Stream Length Ratio (R_L):

R_L is the average of all the stream length ratios between different orders of streams. The mean stream length ratio obtained here is 3.2649 and is given in Table 2.

Table 2 Linear, Shape and Relief parametersof Morphometric Analysis

SL No.	Morphometric Parameters of Noa-Dihing basin	Results
1	Area, A	2178.326 Km^2
2	Basin Perimeter, P	395.9911 Km
3	Basin Length, $L_b = 1.312\,9\ A^{0.568}$	103.2731 Km
4	Total no. of streams, N_u	461
5	Total stream Length, L_u	1389.65 Km
6	Drainage Density $D_d = \frac{L_u}{A}$	0.6383 Km/Km^2
7	Constant of channel maintenance $Cm = \frac{1}{D_d}$	1.567
8	Relative Relief = H - h	4.288 Km
9	Length of overland flow, $L_0 = \frac{1}{2\,D_d}$	0.7833 Km
10	Drainage frequency, $D_f = \frac{N_u}{A}$	0.212
11	Drainage texture (T) (Unit/Km) $= \frac{N_u}{P}$	1.164
12	Form factor, $R_f = \frac{A}{{L_b}^2}$	0.2042
13	Bifurcation ratio, $R_b = \frac{N_u}{N_{u+1}}$	4.3828
14	Shape factor, $S_f = \frac{{L_b}^2}{A}$	4.896
15	Mean Stream length ratio, $R = \frac{L_u}{L_{u-1}}$	3.2649
16	Elongation ratio $(R_e) = \frac{2\sqrt{\frac{A}{\pi}}}{L_b}$	0.51
17	Circulatory ratio (R_c) =	0.1329

ISBN: 978-93-90214-19-8

	$\frac{4\pi A}{P^2}$	
18	Relief ratio (R_h) = $\frac{H}{L_b}$	0.042
19	Ruggedness number (R_n) = D_d*($\frac{H}{1000}$)	2.737

4.3 Linear Parameters

4.3.1 Drainage density (D_d)

In a river basin, D_d is a ratio between total stream lengths of all orders to the total area **[5].** The D_d value for the basin is 0.6383 km/km^2 which shows low drainage density and it is shown in Table 2. It means that highly permeable subsoil materials are available in the regions with vegetative cover **[8].**

4.3.2 Drainage frequency (D_f)

The value of D_f is presented in Table 2**.** For the basin, D_f value is 0.212 stream segments per square kilometer which indicates impermeable underground material having scarce vegetation and lower infiltration capacity **[5] .**

4.3.3 Bifurcation ratio (R_b)

It is the fraction between numbers of streams of a given order to the number of streams of the next higher order **[5].** Here, the mean value of R_h is 4.3828 (Table 2) which specifies that drainage network is unaffected by geological structure and it is a hilly region with high surface run-off and moderate permeability.

4.3.4 Drainage texture (T)

It is a very significant parameter in morphometric study and it is influenced by the geomorphology, infiltration capacity and relief aspect of the topography **[9].** Here T value for the basin is 1.164 and it is shown in Table 2**.** It shows that drainage textures in the basin are very coarse.

4.3.5 Length of overland flow (L_o)

It is defined as the half of the reciprocal of drainage density **[5].** In this study, $L_o$value is 0.7833 and it is given in Table 2. It indicates that the basin is in the initial stage of development.

4.4. Shape Parameters

4.4.1 Form factor (R_f)

The form factor, $\mathbf{R_f}$ for the basin is 0.204 (Table 2). Lower value of R_f infers that the basin has lower peak flows for longer duration **[10].**

4.4.2 Circulatory ratio (R_c)

The value of circulatory ratio for the basin is 0.1329 (Table 2) for the basin and it indicated that the basin has slower discharge and possibility of erosion in the basin is less **[10].**

4.4.3 Shape Factor (S_f)

Noa - Dihing basin has a shape factor of 4.896 and is presented in Table 2. The value of S_f specifies that the basin is not circular and as a result, the time taken by the flood waters to reach the outlet is moderate **[11].**

4.4.4 Elongation ratio (R_e)

R_e value for the basin is 0.51and it is shown in Table 2. This designates a highly elongated basin and it is very prone to soil erosion. Also the basin has less infiltration capacity **[12].**

4.5 Relief Parameters

4.5.1 Relief Ratio (R_h)

Relief Ratio is the fraction between the relative relief and basin length. Relief Ratio, R_h of basin is a dimensionless parameter and its value is 0.042 (Table 2). Lower value of R_h is due to the occurrence of strong underground rocks and lesser degree of slope **[11].**

4.5.2 Ruggedness Number (R_n)

Table 2 shows the value of Ruggedness Number, R_n. Its value for the basin is 2.737. It designates the structural density of the topography with respect to relative relief and drainage density **[12].**

4.5.3 Constant of channel maintenance (C_c)

The reciprocal drainage density is defined as Constant of channel maintenance (C_c) **[13].** In this analysis, the Cc value is 1.567 (Table 2) and shows a higher infiltration rate and higher rock permeability.

4.5.4 Relative Relief (H)

The change in elevation between the highest and the lowest point of the basin is called relative relief, H **[13].** The Basin Relief for the basin is 4.288 km and it is shown in Table 2

CONCLUSION

This study validates the efficacy of Remote Sensing and GIS for morphometric analysis using linear, form and relief parameters in the Noa-Dihing river basin. The results of different morphometric parameters calculated here show that the shape of the basin is elongated and that the peak flow for the basin is low with a longer length. So the flood flow is very difficult to control and the basin becomes vulnerable to soil erosion. In the assessment of river basins, soil degradation, basin management and prioritization of watersheds for soil and water protection at the lowest level, the present study will be of tremendous importance.

REFERENCES

[1] Gajbhiye et al. (2013), Proritizing erosion-prone area through morphometric analysis: an RS and GIS perspective, Applied Water Science, pp-1-11.

[2] Strahler, A.N. (1968). Quantitative geomorphology In: Fairbridge, R.W. (eds).

[3] Horton, R.E. (1932), Drainage-basin characteristics, Transactions, American geophysical union 13, pp-350-361.

[4] Strahler, A.N (1964), Quantitative geomorphology of drainage basins and channel networks. In: V.T. Chow (ed), Handbook of Applied Hydrology. McGraw Hill Book Company, New York, Section 4II.

[5] Horton, R.E. (1945), Erosional development of streams and their drainage basins; hydrological approach to quantitative morphology, Geological Society of America Bulletin 56.

[6] Meshram, Sarita Gajbhiye, and S. K. Sharma. "Prioritization of watershed through morphometric parameters: a PCA-based approach", Applied Water Science, 2015.

[7] Nooka Ratnam, K et. al (2005),Check Dam Positioning By Prioritization Of Micro-Watersheds Using Syi Model And Morphometric Analysis – Remotesensing And GIS Perspective, Journal of the Indian Society of Remote Sensing, Vol. 33, No. I. 2005

[8] Sarma P.K., Sarmah K., Chetri P.K. and Sarkar A. (2013), Geospatial study on morphometric characterization of Umtrew River Basin of Meghalaya, India, Interanational Journal of Water Resources and Environmental Engineering, Vol.5 (8), pp.489-498.

[9] Strahler, A.N.(1952), Dynamic basis of geomorphology. Geological Society of America Bulletin 63, pp. 923- 938.

[10] Miller VC (1953) A quantitative geomorphic study of drainage basin characteristics in the Clinch Mountain area, Varginia and Tennessee, Project NR 389042, Tech Rept 3., Columbia University, Department of Geology, ONR, Geography Branch, New York

[11] Strahler, A.N. (1957). Quantitative analysis of watershed geomorphology. Transactions American Geophysical Union, 38, pp. 913-920.

[12] Strahler, A.N. (1958): Dimensional analysis applied to fluvially eroded landforms. Geological Society of America Bulletin, 69: 279-300.

[13] Schumm, S.A. (1956). Evolution of drainage systems and slopes in Badlands at Perth Anboy, New Jersey. Bulletin of the Geological Society of America, 67, pp. 597-646.

 ISBN: 978-93-90214-19-8

Utilization of waste materials in brick manufacturing process: A Review

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Abstract - The present scenario says, an alternate for clay bricks is fly-ash bricks because of its less Weight and low cost such fly ash bricks not subjected to load bearing structure because of its silent reduction in compressive strength as compared to normal clay bricks. To overcome the issue and concern for sustainable technology has increase research activities on the production of more durable construction materials. Rice husk ash (RHA) has successfully been used as supplementary material in concrete, improving both strength and durability due to high pozzolanic activity. The study focus on reuse and recycle the available waste generated to find socio-economical, eco-friendly and cleaner environment and also to study or practical the feasibility or producing brick using agriculture waste material rice husk, coir, granite powder in varying percentage. Properties such as compressive strength water absorption, hardness, soundness is determined.

Keywords: Rice husk ash; Coconut coir; Granite powder; clay soil

INTRODUCTION

It is estimated that India has more than 100,000 brick kilns producing about 250 billion bricks, consuming about 35 million tons of coal generates 26 million tons of Carbon Dioxide annually. Nowadays the brick industry is growing as the demand for bricks is increasing in the towns and villages due to the fast economic growth, urbanization and prosperity. It is alarming to note that 300 mm depth of fertile top soil in India will be consumed for burnt clay brick production in about 60 year. A 10% switchover to fly ash bricks will use 30 million tones of fly ash every year, which save environment and coal. There has been impressive increase in the power generation in India from a low capacity of 1362 MW in 1947 to about 377261 MW in March 2021. Indian coal has high ash content around 35-45% and low calorific value 35004000 KCal/Kg as a result of which huge quantity of ash is generated. A typical 200 MW unit produce around 50-60 M Tons of ash per hour in India. Generally 0.40 hectare land is needed per M.W. of power production. (2)

As per the studies done on this flyash bricks show some reduction in the strength when compared to conventional bricks, to overcome that issue and to increase the strength of the brick and agricultural wastes were added with half proportion of sand. Agricultural wastes such as oil palm, pineapple leaves, sugarcane bagasse ash, paper pulp, coconut coir, rice husk, rice straw, jute, hemp, corncob and sawdust were used in production of cement-based composites. Based on various researches, the utilization of natural fibre reinforced cement composites offer several advantages, e.g., increased flexural strength, post-crack load bearing capacity, improved bending strength, etc. and also stated that the use of coconut fibers increase the strength and to have better performance than the conventional bricks, coconut fibers were incorporated and the performance of the bricks were analyzed. Though the rice husk ash is also having pozzolanic properties like fly ash it can be used as a replacement material for the fly ash. When the rice husk ash is used as additive to increase strength it shows poor performance, because it is also in the powdered form, so it cannot engage to the strength parameters of the brick so it can only be used as a filler material. Granite powder is another material used in the brick to fill the remaining vacant, space. Because of its properties it is used in the combination form of powdery and gravel particles, though the powdery particles does not enhance the strength parameters, somewhat coarser particles were mixed which helps to the strength parameters of the brick. Granite powder is obtained from the granite crushing process produced during quarrying activities and due to the easy availability and the low cost it is used in plenty of works like cement mortar, building block, concrete and in controlled low strength material these quarry dust is incorporated as a main ingredient in the building industries.

OBJECTIVES

1. To study the Physical and geotechnical properties of Black cotton soil, Red soil,Ricehusk ash, Granite powder and Coconut coir as per relevant manuals or IS codes.
2. To manufacture bricks using Black Cotton soil, Red soil and water, after arriving to a proper proportion by trial and error method.
3. To study physical properties of manufactured bricks by conducting various tests as per relevant IScodes.
4. To arrive effective cost per manufactured brick.

MATERIALS

A. Rice Husk Ash (7)

In large quantities Rice milling industry generates a lot of rice husk during milling of paddy which comes from the fields. This rice husk is mostly used as a fuel in the boilers for processing of paddy. . After burning Rice husk ash (RHA) by natural way it is weighs about 25% by weight of rice husk. A fire source was maintained after which the husks slowly burned for more than one day. The ash was left after burning is allowed to cool down before it was collected. It possesses a chemical composition similar to many of the organic fibres. Rice husk ash consists of Cellulose (C5H10O5), Lignin (C7H10O3), Hemi cellulose, SiO2, Holo cellulose. These are compounds within them in common. The rice husk ash may show some variation depending upon the source as well as the type of treatment. It treated in such a way that rice husk is burned to have proper properties.

B. Granite Powder (Quarry Dust)(8)

Granite powder is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying for different activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste. It is generally grey in colour and it is like fine aggregate. Density of natural granite powder is 2700 kg/m2 .The specific gravity was found to be 2.58 to 3. After a replacement of natural fine aggregate by quarry dust which is highlighted in the various, study could boost the consumption of quarry dust generated from quarries. Because of the availability of sand at low cost as a fine aggregate in concrete is not suitable and that is the reason to search for an alternative material and the granite powder is used in order to increase the strength of the brick. When we use this quarry dust, their hardening period is reduced and it bonds quickly because of cementitious properties on another hand when we use lime, gypsum, their hardening period and due to powdery form they need to be compressed at high load.

C. Coconut Coir Ash (4)

Coconut Coir is a natural fibre extracted from the husk of coconut and used in products such as floor mats, doormats, brushes and mattresses. Coconut coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. It contains properties which improves water retention ability, including its ability to be easily re-hydrated. It also possesses aeration properties which are important in soilless growing.

Element compositions of CHA at different temperatures.

Element	Percentage of Compositions (%)
	500 °C
SiO_2	8.09
CaO	27.93
K_2O	19.85
Al_2O_3	0.76
SO_3	3.12
Fe_2O_3	1.09
P_2O_5	0.27
Cl	37.28
Others	1.61

Table 1 [11]

D. Soil(9)

Soil extracted from the Earth surface are important for brick quality, the present study was conducted to characterize brick making soil in esteem of geo-engineering properties (specific gravity, liquid limit, plastic limit, plasticity index, liquidity index and linear shrinkage), elemental analysis and thermal properties. This work will provide background information about different properties of brick making soil and factors to optimize the soil suitability criteria for making bricks of long life span.

Properties	Particular Method	Using Formula
Moisture Content (W)	Oven-drying Method	$W = \frac{m_2 - m_3}{m_3 - m_1} \times 100$ Where, m_1= Mass of container (gm), m_2= Mass of wet sample and container (gm), m_3= Mass of dry sample and container (gm)
Specific Gravity (Gs)	Small Pycnometer Method	$Gs = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$ Where, m_1= Mass of the small dry pycnometer (gm), m_2= Mass of the dry pycnometer and dry soil (gm), m_3= Mass of the pycnometer, soil and water (gm), m_4= Mass of the pycnometer and water (gm)

Table 2 [12]

Properties		Particular Method	Using Formula
Atterberg Limit	Liquid Limit (LL)	Fall Cone Penetro-meter	Relationship between cone penetration and moisture content was plotted in semi-log paper where cone penetration was plotted on log scale. Moisture content corresponding to a cone penetration of 20 mm was taken as the liquid limit of the sample.
	Plastic Limit (PL)	Rolling Thread Method	$PL = \frac{m_2 - m_3}{m_3 - m_1} \times 100$ Where, m_1= Mass of container (gm), m_2 = Mass of thread of sample and container (gm), m_3= Mass of dry thread of sample and container (gm)
	Plasticity Index (PI)		$PI = LL - PL$ Where, LL= Liquid limit (%), PL= Plastic limit (%)
	Liquidity Index (LI)		$LI = \frac{W - PL}{PI}$ Where, W= Moisture content of the sample (%), PL= Plastic limit of the sample (%), PI= Plasticity index of the sample (%)
Linear Shrinkage (LS)		Oven-drying Method	$LS = \frac{L_1 - L_2}{L_1} \times 100$ Where, L_1= Initial length of the sample (cm), L_2= Oven dried length of the sample (cm)

Table 3 [12]

METHEDOLOGY [10]

i. The study of properties of raw materials by referring the relevant IS codes and Manuals.
ii. After comparing and arriving at the proper proportions using the raw materials.
iii. Manufacturing of bricks by series of trials using various proportions.
iv. For manufacturing of bricks traditional method should be used which includes the following steps:
a. Preparation of clay
b. Moulding and
c. Burning
v. Tests should be taken on manufactured bricks as per relevant IS codes.

Procedure for manufacturing Bricks

1. Removal of top soil: the removal of top soil up to 200mm depth, this material should be removed as it contain a lot of impurities and are not used in the preparation of bricks.
Digging and spreading: after digging the soil for about 200mm, the soil is a spread on the level ground ,and heaps of clay about 600 to 1200 mm.
Cleaning: The soil should not have stones, vegetable matter, pebbles etc. If these particles are in excess the clay is not a washed and screened, and lumps in soil should be crushed into a powder form.
Weathering: The soil is then exposed to the atmosphere for a softening for a few weeks depending on the nature of the soil.
2. Adding ingredients: To increase the strength of soil by adding ingredient at suitable proportions along with a rice husk ash burnt at temperature of 6000oC to 9000oC, Coconut coir burnt at 500oC and granite powder collected from granite shops.
3. Mixing: The whole mass is mix uniformly with water and mixing can be done by hand.
4. Moulding of bricks: when clay is a prepared moulding in a done and the brick cast in a size 19cm x 9 cm x 9cm.
5. Burning of bricks: Before burning drying of a brick necessary, so that they are sufficient hard to be handed and stock in the burning kiln without any injury. Brick are burn to import hardness and strength to brick and increase the density. The brick have been burnt in a clamp or kiln at a temperature at 700oC for 7 day.

ACKNOWLEDGEMENT
The Authors are thankfully to Dr. Devendra.P Singh,Principal,KDKCE,Nagpur. Dr. Valsson Varghese, Professor & Head of Civil Engineering Department, for his guidance and his valuable suggestions. We are also thankful to Prof. Anshul R Nikhade and all other faculty members of Civil Department, KDKCE, Nagpur for their valuable inputs and suggestions.

REFERENCES

[1] Arul Surya M1,"Enhancing the Compressive Strength of the Fly Ash Brick by Fibre Reinforcement", Volume 4, 2456-2165, July 2019
[2] Amin Al-Fakih Bashar S. Mohammed, "Incorporation of Waste Materials in the Manufacture of Masonry Bricks",An Update Review, S2352-7102(18)30203-1, 2018

[3] Hubli Kiran, Beedimani Priyanka, Aishwarya, Karale Suneel, "A Study on Manufacturing of Bricks using Black Cotton Soil & Red Soil", IFERP, Vol 3, Issue 5, May 2018.
[4] Muhammad Fahmi Anuara, Yap Wing Fena, Mohd Hafiz Mohd Zaida, Khamirul Amin Matoria, Rahayu Emilia Mohamed Khaidirb, "Synthesis and structural properties of coconut husk as potential silica source" Elsevier 2018.
[5] Mohammad Shahid Arshad, DR. P.Y. Pawade, "Reuse of natural waste material for making light weight bricks" Volume 3, 2277-8616, June 2014
[6] N.Vamsi Mohan, Prof.P.V.V.Satyanarayana, Dr.K.Srinivasa Rao,"Performance Of Rice Husk Ash Bricks"Volume 2, 2248-96225, 2012
[7] Rafid Shams Huq, Farhana Chowdhury,"Use of Rice Husk Ash as Substitute to Make Clay Bricks",Volume 7,2319-8753, 2018
[8]S.P.Raut,R.V.Ralegaonkar,S.A.Mandavgane,"Development of sustainable construction material using industrial and agricultural solid waste: A review of waste-create bricks",5 May 2011
[9] Tanveer Mehedi Adyel, Syed Hafizur Rahman, S M Nazrul Islam, Hossain Md Sayem, Tanveer Mehedi Adyel."Characterization of Brick Making Soil: Geo-engineering, Elemental and Thermal Aspects" 2012 Jahangirnagar University Journal of Science Vol. 35, No.1, pp. 109-118

Case Study on Construction Methodology of Precast Un-Reinforced Lithelyarch® Bridge at Panchgani Satara

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Abstract - The arch bridges have been there since many centuries. Construction of stone arch bridge is time consuming process. It requires precise stone cutting and heavy formwork due to which stone arch bridges have been obsolete and replaced with R.C.C bridges. At that time construction of R.C.C bridges was fast process than the stone arch bridges and was adopted widely. This R.C.C bridges were needed to be replaced before its design life due to its corrosion problems. This study deals with the construction methodology of LITHELYARCH® bridge constructed at Panchgani without any structural reinforcement and in short duration of 4 months. As pre-casting is involved in the construction process of LITHELYARCH® bridge hence resulting in speedy construction. Precast unreinforced LITHELYARCH® bridges are same as stone arch bridge with advancement in construction methodology. For construction of LITHELYARCH® bridges flexible arch strip is prepared by casting individual PCC blocks connected with wire ropes which is only for lifting of arch strip. This flexible arch strip is then transported from casting yard to construction site with the help of trailers. This arch strip is then placed on sockets above pier/abutment or foundation. As LITHELYARCH® load transfers mechanism is in Pure compression there is no requirement of structural steel. The maintenance cost required during life cycle of LITHELYARCH® bridge is less than conventional R.C.C bridges. The design life span of LITHELYARCH® arch bridges is 120 years has there is no structural steel used which causes corrosion and decrease design life of bridges. LITHELYARCH® bridges gives pleasant view and aesthetic appearance to surrounding.

Keywords: Bridge Engineering, Arch Bridge, LITHELYARCH® Bridge, Flexible Arch, Precast Arch.

INTRODUCTION

The construction of masonry arch bridges by conventional method is no longer to sustainable due to un-availability of precise shape masonry blocks and skilled workmanship and accurate centring required to build bridges. The construction progress of masonry arch bridges is considerably depending on whether condition. But old masonry bridges are still standing in working condition with regular traffic flow on it.

This case study is based on construction methodology of LITHELYARCH® bridge, all elements in LITHELYARCH® bridge are constructed without any structural reinforcement. The sub structural elements i.e. (foundation, pier) are constructed in PCC and arch strip in super structure were constructed with precast PCC blocks. Arch strip is constructed from individual precast PCC trapezoidal concrete blocks. As in complete structure there is no use of structural steel so issue of corrosion not arises, this increases design life of structure. The LITHELYARCH® bridge is one of the best solutions for rapid construction with cost effective and longer design life of structure. The public works department (PWD) government of Maharashtra recommends use of precast PCC arch bridges. These bridges already in service in various cities like Nagpur, Yavatmal and Satara. LITHELYARCH® bridges gives pleasant view and aesthetic appearance to surrounding.

SALIENT FEATURES

• No structural reinforcement is used in complete structure. as the structure is pure compression member.

 ISBN: 978-93-90214-19-8

• The bearings are not required in lithely arch technology.
• Less maintenance cost as compare to regular bridges.
• Accelerated Construction.
• Centring is not required.
• Long design life.
• Aesthetic view.

Site Location and details of Structure:

Bridge site is located on pachgani – kudal road MDR-25 at km 8/800 (GPS-15.796847,74.101097).
1) Total length of bridge – 24.62 m.
2) Clear Span – 6.08 m, Rise – 2.61 m.
3) No. of span – 3 nos.
4) Carriage way width – 4.25 m.
5) 15 no. of strips was used in this project.
6) Thickness of arch ring is 400 mm in 1000 mm width and total length of strip is 9.88 m.
7) Provide gabion structure as retaining structure.
This structure is elevated and its height from foundation to R.T.L is 8.00m

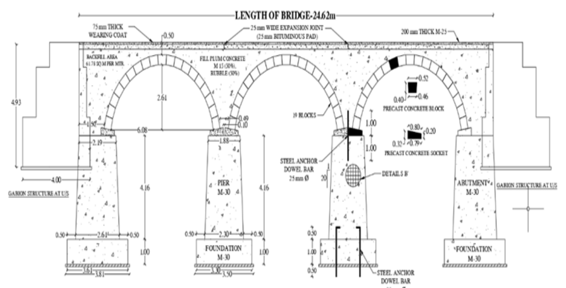

Fig.4.1 Longitudinal section of arch bridge

4.1 PRECAST CONCRETE BLOCK:
• Dimensions and details of precast concrete block
1) Weight of each block = 470.40 kg.
2) Number of blocks in each strip = 19 Nos.
3) Total number of blocks in bridge = 285 Nos

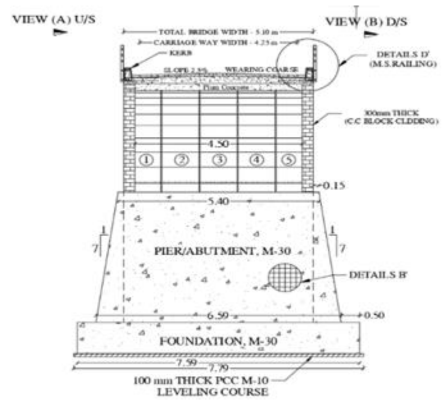

Fig.4.2 Arch section of arch bridge

4.2 PRECAST CONCRETE SOCKET:
• Dimensions and details of precast concrete block
4) Weight of each socket = 491.68 kg.
5) Number of sockets in each strip = 2 Nos.
6) Total number of sockets in bridge = 30 Nos

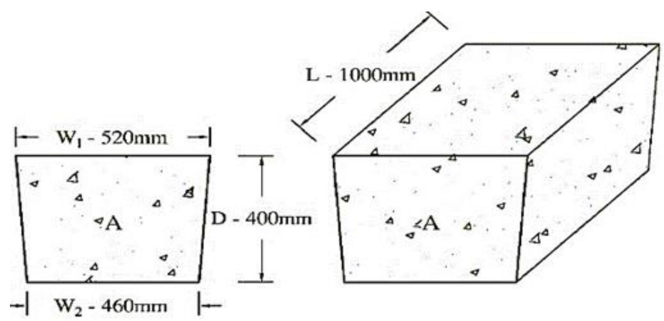

Fig.4.1: Precast PCC block

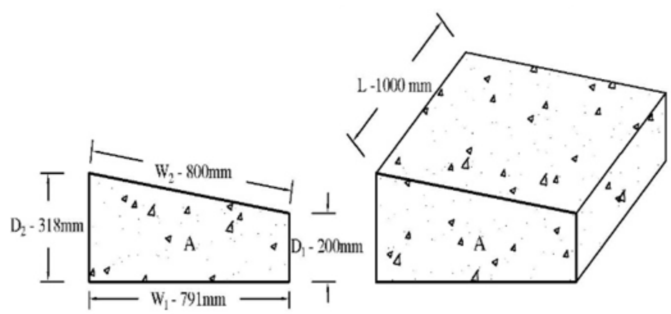

Fig.4.2: Precast PCC Socket

4.3 LITHELY ARCH STRIP:
• Dimension & details of precast LITHELYARCH® strip.

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1) Span of arch ring = 6.08 m
2) Rise of arch ring = 2.61 m
3) No of blocks in each strip = 19
4) Total weight of Arch strip = 10.33 T
5) Thickness of arch Strip = 400 mm
6) Width of arch strip = 1000 mm
7) Total number of strips in each span = 5 Nos.
8) Total number of spans in bridge = 3 Spans

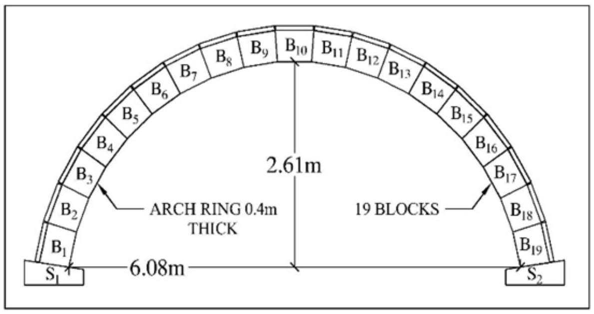

Fig 4.3: Arch Strip Details

Pre-casting activities of LITHELYARCH® bridge:

• Pre-casting of concrete block.

Pre-casting of individual PCC blocks were done in precisely fabricated steel mould. steel rings are provided as a hook in each block for lifting purpose only. These concrete blocks were placed on levelled H-frame (steel frame). Those concrete blocks were also lined up in a straight line on H-frame.

Fig.5.1.1: Steel mold for block casting

Fig. 5.1.2: Remove block from mold

Fig.5.1.3: Blocks arranged line and leveling

• Pre-casting of concrete socket.

Precisely fabricated steel mould was prepared for the casting of PCC socket. Firstly, socket placed over pier top and then arch strip is simply placed over socket. A precast socket transfer load from the arch ring to pier/abutment and then to foundation. Socket also accommodate the angle of blocks at both ends of the arch ring. Two Sockets are required for each ring on either end.

Fig.5.1.4 Steel mold for socket casting

Fig.5.1.4 Precast PCC Socket

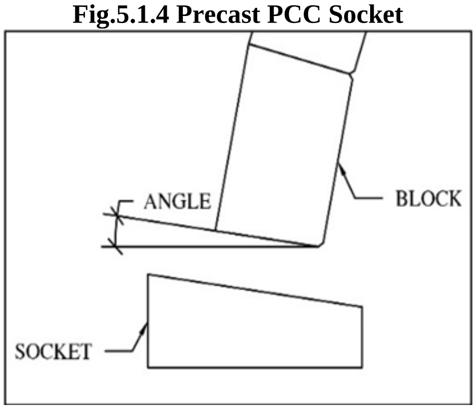

Fig.5.1.5 Angle of end block

- Placing wire rope and Screed Concrete

1) Wire Rope and Ferrules:

Wire ropes were used to connect the individual blocks into a single unit and to give flexibility to the arch. Wire ropes were provided on top of precast concrete blocks. Wire rope is sandwiched between the precast block and screed concrete. Blocks are held together by wire ropes placed on top of blocks. These wire ropes are purely for lifting purpose and support the dead load of the arch unit while lifting process.

Aluminium ferrules were provided in each wire rope at the centre of the block. Ferrule helps to create a bond between wire ropes and screed concrete. Steel anchorage bar of 8 mm diameter and 150 mm long is placed between wire rope and ferrule during crimping. These anchorage bars provide a bond between screed and wire rope through ferrules.

2) Screed Concreting:

The screed concrete of 60mm thickness was provided on top of precast PCC blocks. Z-section plate was used as shuttering from outer side and separation plate was used to separate screed concrete on each block. Screed concrete provides fixity between wire rope and PCC blocks.

Fig.5.1.6: Wire rope placed on Blocks

Fig.5.1.7: Ferrules and Rod

Fig.5.1.8: arch Strip with screed concrete

- Lifting of the arch strip.

1) Lifting Arrangement:

The arrangement for lifting of arch strip consists of lifting beam, polyster slings, D-shackle, chain pully and crane of desire capacity. The lifting beam was

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prepared by two ISMC-300 sections connected face to face by 6mm steel plate which makes the section size of 300mm x 300mm and length of lifting beam was 6 m. Lifting beam consists hole of 40 mm diameter of 200 mm c/c was provided. The polyster slings are connected to arch strip and lifting beam which is eventually connected to crane. Two sets of chain pully were used to get the desired arch shape from arch strip. D-shackle of 25T, 10T and 5T capacity was used to connect slings to slings and slings to arch. The arch strip was lifted from 3 point i.e center and two 1/3rd point on each side.

Fig.5.1.9 Lifting Arrangement

2) Half lift of arch strip.

The strip was half lifted and placed on trailer at casting yard so as to transport arch strip to site. Purpose of half lift is to load strip on the flat bed trailer. When the half lifted arch strip is loaded on trailer its regain its flat shape. For transportation of arch strip, a flatbed trailer of 40ft was required to accommodate the length of arch strip i.e. 34 feet. Two arch strips were loaded on trailer at a time. Sand bag were placed above trailer to absorb the vibration while transportation. H-frame was place above the sand bags on trailer for levelling purpose.

Fig.5.1.10 Half lift of arch strip

Fig.5.1.11 Arch Strip placed on trailer for transportation

On-site activities of LITHELYARCH® bridge:

• Excavation and cast-in-situ Foundation

As exposed rock was available at site open foundation was proposed. As per IRC-78 and PWD guidelines the bottom of foundation should be 1.5 m in exposed rock or soft rock. At the site the foundation bottom was specified in drawings, the foundation block was proposed in PCC M-25 grade. 25 mm dowel bar was provided at 1 no’s per Sq.m embed in rock through footing into pier for connection purpose only.

Fig.5.2.1: Excavation for foundation

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Fig.5.2.2 Cat-in-situ of foundation

• Cast-in-situ pier or abutment
MS steel plate shuttering was used for the casting of pier and abutment. Casting of pier and abutment was done in lift of 1m.

•Socket Placed on Pier Top
Precast socket was placed on top of piers and abutment. The sockets are lifted and placed with the help of hydra 6.5T lifting capacity. Sockets accommodate the angle of blocks both ends of the arch ring. The socket is used to transmits the load from super structure to the pier and abutment. As shown in fig 5.2.4

Fig.5.2.3 Cast-in-situ pier and abutment

Fig.5.2.4 Socket placed on pier top

• Full lift of arch strip and placed on socket:
Full lift is the process in which arch strip is lifted from trailer and simply placed over socket. While full lifting the arch strip gets its desired shape of arch and hence called as full lift. The process done with the help of crane for this particular project 100MT capacity of crane was used. The movement of arch strip from trailer to socket is controlled by nylon rope and chain pully. This process is done specialised controlling. As Shown in fig 5.2.5

Fig.5.2.5 Full Lift of Arch Strip

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Fig.5.2.6 Spandrel wall and Plum filling

• Cast-in-situ spandrel wall and Plum filling above the arch

Plum concrete of M15 grade (50% plum and 50% concrete) were filled above arch ring. Spandrel wall was used as permanent shuttering. Filling of plum Concrete was done in layer of 1m. As Shown in fig 5.2.6

•Bridge Finishing:

Texture painting for aesthetic view was provided

6. Quantity and grade used in this project.

SR.NO	**ITEMS**	**TOTAL VOLUME (CU.M)**
1	LEVELING COARSE (M-10)	
	a) FOR ABUTMENT	3.21
	b) FOR PIER	3.12
		6.33
2	FOUNDATION (M-30)	
	a) FOR ABUTMENT	60.09
	b) FOR PIER	85.74
	TOTAL	145.8253
3	ABUTMENT (M-30)	72.89
4	PIER (M-30)	128.66
5	PRECAST SOCKET (M-50)	
6	TOTAL VOLUME OF SOCKETS	8.08
7	ARCH STRIP (M-50)	
8	TOTAL VOLUME OF STRIP	128.8
9	BACK FILL (M-15) (50% CONCRETE & 50% RUBBLE)	118.41
10	LOAD DISTRIBUTER (M-20)	46.01
11	WEARING COAT (M-20)	14.38
12	KERB	7.04
Total		**676.420 CU.M**

Table No. 6.1: Volume of Concrete

SR.NO	**SECTION**	**GRADE OF CONCRETE**
1	WEARING COAT	P.C.C M-20
2	KERB	R.C.C M-30
3	LOAD DISTRIBUTER	P.C.C M-20
4	BACK FILL	PLUM CONCRETE M-15
5	SCREED	P.C.C M-50

	CONCRETE	
6	ARCH RING	P.C.C M-50
7	PRECAST SOCKET	P.C.C M-50
8	ELEVATED ABUTMENT	P.C.C M-25
9	ELEVATED PIER	P.C.C M-25
10	FOUNDATION	P.C.C M-25
11	LEVELING COURSE	P.C.C M-10
12	ANNUAR FILLING	P.C.C M-15

Table No. 6.2: Grade of Concrete

CONCLUSION

Case study for construction of arch bridge by LITHELYARCH® technology was successfully completed and following conclusions are made out from the study

• LITHELYARCH® technology is effective construction technology for arch bridges.

• As per study the design life span of arch bridges is more than the conventional R.C.C. slab bridges.

• The LITHELYARCH® technology can replace the construction methodology of conventional masonry arch bridge due to ease in construction.

• Due to use of steel moulds for the casting of blocks and sockets, finishing and dimensions are achieved precisely.

• No structural steel is used in LITHELYARCH® bridge, hence makes this the most suited bridge in coastal areas.

• The pre-casting, lifting and placing with the help of crane reduces the construction time of the arch bridge.

• Cost of maintenance during the life span of this LITHELYARCH® bridge is lesser than the conventional bridge as the maintenance required is too less.

REFERENCE

[1] Mr. S.S Bhonge et. al., “LITHELYARCH® Bridge – Construction of Precast, Un-Reinforced Arch Bridge for Maharashtra PWD at Koregaon, Satara”. IRC INDIAN HIGHWAYS, Volume: 48, Number:2, Feb/2020, Page No. 17-29

[2] Gupta A and Hogg I “MONITORING OF MONKSTOWN BRIDGE A NOVEL FLEXI-ARCH BRIDGE SYSTEM,” ARCHIE-M: Masonry Arch Bridges and Viaduct Assessment Software, Version 2.0.8, OBVIS Ltd. UK, 2006.

[3] A. Long, A. Gupta, D. McPolin and D. Courtenay, “INNOVATIVE METHOD FOR THE RAPID CONSTRUCTION OF ARCHESIstanbul Bridge Conference August 11-13, 2014 Istanbul, Turkey.

[4] Long, A., McPolin, D., Kirkpartick, J., Gupta, A., & Courtenay, D. (2014). FlexiArch: from concept to practical applications. Structural Engineer, 92(7), 10-15.

[5] “Wire rope hand-book”, Usha Martin, available online at ushamartin.com.

[6] IRC:5-2015, “Standard Specifications and Code of Practice for Road Bridges”, Section I – General Features of Design (Eighth Revision). Indian Road Congress, New Delhi.

[7] IRC:6-2017, “Standard Specifications and Code of Practice for Road Bridges, Section-II Loads and Load Combinations” (Seventh Revision). Indian Road Congress, New Delhi.

[8] IRC:112-2011, “Code of Practice for Concrete Road Bridges”. Indian Road Congress, New Delhi.

[9] IRC: SP:13-2004, “Guidelines for the Design of Small Bridges and Culverts” (First Revision). Indian Road Congress, New Delhi.

[10] IRC: SP:51-2015, “Guidelines for Load Testing of Bridges” (First Revision). Indian Road Congress, New Delhi.

[11] IRC: SP:61-2004, “An Approach Document on Whole Life Costing for Bridges in India”. Indian Road Congress, New Delhi.

[12] IRC: SP:82-2008, “Guidelines for Design of Causeways and Submersible bridge”. Indian Road Congress, New Delhi.

[13] IRC: SP-105-2015, “Explanatory Handbook to IRC:112-2011: Code Practice for Concrete Roads Bridges”. Indian Road Congress, New Delhi.

 ISBN: 978-93-90214-19-8

Practical Strategies - Cutting Through the Complexity of Nanthoor Junction

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Abstract - From the past few years, the road users at Four Way Junction of Nanthoor, in the city of Mangalore, have been facing problems of traffic congestion. Traffic volume at Nanthoor junction is found to be drastically increasing day by day, as it serves as a linking site connecting nearby cities making it the busiest intersection of the city. A long trail of vehicles waiting to clear a stretch of one kilometre is a daily scene at Nanthoor. Further, Dysfunctional signals at the potential site have magnified the problem further to a larger extent, resulting in accidents, thereby decreasing the Operational Efficiency of the Road.

The present study focuses on Traffic Congestion studies on the intersection of Nanthoor and thereby suggesting providing measures for the traffic congestion. An attempt is made to study the effect of installed Rotary in congestion problem at the potential site which is most vulnerable to accidents. In the present study, calculation of Practical capacity was done considering the existing geometric dimensions of rotary and further, an attempt was made to re-design the rotary as per IRC 65:1976 guidelines for urban roads in order to have an increased capacity of rotary thereby reducing the major problem of traffic congestion.

Index Terms - ***Rotary Design, Traffic Congestion, Practical Capacity, Traffic volume***

I. INTRODUCTION

Congestion on the urban roads of India are afflicting vehicle stockpile and effects the urban economy in different ways. Congestion may be defined as excess demand for travel over its supply. The occurrence of congestion on the city roads prevent the movement of traffic and leading to the intolerable increase in the trip delay. Accelerating the above issue, accidents have become a major issue in the modern era, which has been resulting in injury and death of human lives. Indeed, even in the least urbanized countries like Afghanistan, Sri Lanka; road accidents have become the common cause for deaths and injuries. The increasing urbanization and economic growth of India has resulted in increasing the average accidental rates throughout the country. According to the researches in the year 2013, it has been observed that about 137000 people have died due to the road accidents. In India, the main cause of road accidents is due to the congestions occurring in the urban areas and the improper road geometrics.

From the past studies, it was found that the potential problem in a rapidly growing cities like Mangalore have been traffic congestion problems and increased records of Accidents. The major reason for the problem of traffic congestions have been increased vehicular traffic, reduction of usage of public transport, increased population, faulty traffic signals at intersections, etc making the traffic lines less effective. Further, past accident studies revealed that more than 41 percent of the road accidents have been reported in eleven places across Mangalore. Some of the factors that influence the road accidents at the junctions are: Improper road design and conditions like presence of potholes, Low maintenance of traffic signals, rules, or failure of vehicle components like brakes, tires, lights, etc and due to the psychology of the road users.

The present study largely focuses on one of the most congestion prone spots in the Mangalore city which is the Nanthoor intersection. The heavy traffic jam and accidents at the peak hours have been a major area of concern. An aerial view of Nanthoor Intersection has been displayed in the figure 1.

Fig. 1: Aerial view of Nanthoor Intersection

II. OBJECTIVES

- To study the Congestion problem at Nanthoor intersection and highlight the major causes for the same.
- To study the effect of installed Rotary in congestion problem at the potential site.
- To compute Practical capacity for the existing geometric dimensions of rotary and re-design the rotary as per IRC 65:1976guidelines for urban roads

III. LITERATURE REVIEW

Sitesh Kumar Singh and Karan Prabhakar, et.al.[1] (2017) conducted study on statistical analysis of traffic rotary Intersection to decrease the traffic delays and accident and also to analyse the necessary design improvements of rotary intersection and further development of extension if needed for the present rotary. And the conclusion drawn were the engineer needs to design methods based on fundamental relationship between geometry, capacity and safety that will enable commuters to get directly from proposed geometry to the realistic estimates of operating condition.

Monusha chowdri N, et.al.[2] (2019) investigated extent of road traffic accidents in mangaluru city, Karnataka. To find out the main causes for road accidents in mangaluru city. To find out which vehicles are most involved in road accidents. To suggest measures to road accidents in city of mangaluru and the conclusions drawn where the road accidents were caused mainly due to rash and negligence driving as they do not follow the traffic rules and laws, Road accidents occurs at peak hours and weekends, people rush to work or school. During weekends and at night there are more, accidents as they over speed because there will be less traffic and will tend to drive/ride in wrong side of road.

K P Deepdarshan, et.al.[3] (2010) conducted a case study of blackspot at mangaluru city and proposal of mitigation measures to study the causes of accidents and to suggest correcting treatment at potential location. To enter out before and after studies and to demonstrate the improvement in the problem and the conclusions drawn where Few short-term measures include- providing adequate road furniture, speed breakers, lane markings pedestrian crossing are proposed as mitigation measures. Long term measures involve -widening of pavement and shoulder, traffic signal provision of road humps and underpass.

IV. METHODOLOGY

The primary objective of the present work is to find out major reasons for the ineffectiveness of the intersection and thereby find out the mitigation measures so as to reduce the congestion problem at the potential site. The sequential procedure carried for the entire study is highlighted in the flowchart mentioned in Figure 2.

ISBN: 978-93-90214-19-8

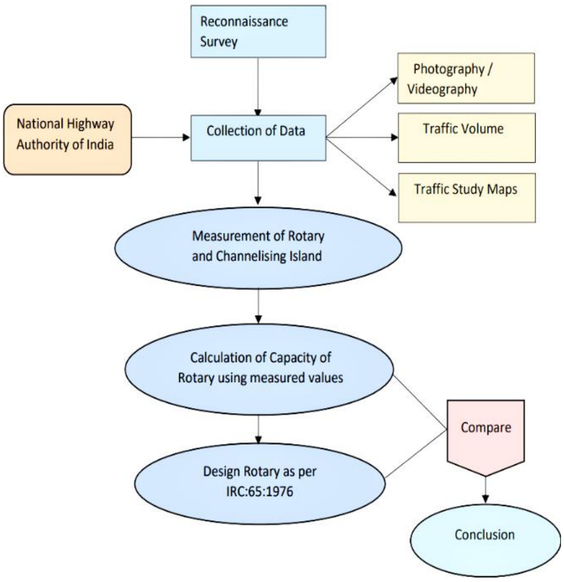

Fig 2: Flow diagram displaying the methodology.

Reconnaissance Survey:

An extensive study on the entire intersection was performed at Nanthoor, the whole sectional plan was analysed through an aerial view from an existing building located around Nanthoor intersection, in which a study on rotatory was carried out to differentiate the existing plan corresponding to the Indian Road Congress.

Collection of Data

Various data were collected during the survey and also by visiting the National Highway Authority of India such as, Traffic flow pattern, Vehicle volume count and Traffic study maps.

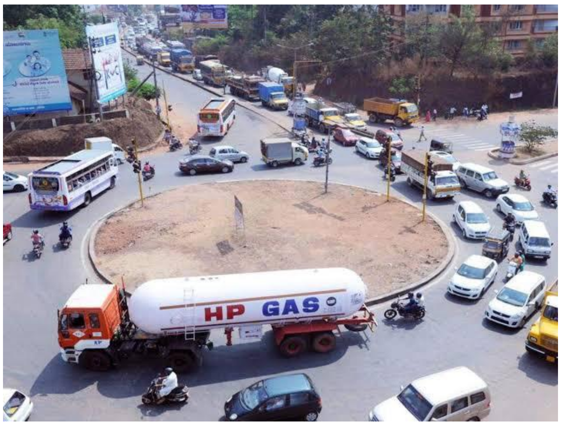

Fig. 3: Intersection with Large Central Island

Fig. 4: Present Condition at Nanthoor Intersection

A. Traffic flow pattern:

A detailed survey was performed at Nanthoor intersection in the peak hours (8:00 – 10:00 AM and 5:00 – 7:30 PM) by video-photography method. Analysis was done conveniently with the help of video to study the traffic flow pattern. The vehicular movement were studied across the rotary and it was observed that the difficulty in transiting towards weaving section was the main cause for congestion. It was found that the road users traveling from Udupi to Moodbidri route had to decrease the speed at weaving section, thereby increasing the delay time causing congestion problem. Further, it was observed that the large turning radius that had to be taken by the vehicles travelling at central island portion of rotary was adding on to the delay in movement of vehicles thus adding to congestion problem at potential site.

B. Vehicle volume count:

Volume of traffic is the number of vehicles passing a known section of road at a given interval of time.

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The flow of traffic is expressed in Passenger Car Unit (PCU). Traffic volume count was obtained from the National Highway Authority of India. Traffic volume count were collected for all the four routes leading towards Nanthoor intersection. Further, a study was conducted to find the proportion of the weaving traffic with the data provided by the NHAI. This data is necessary for computation of Practical capacity of Rotary section.

C. Traffic Study Maps:

Traffic study maps are utilised to determine the design speed, super-elevation and the coefficient of friction. these data are entirely dependent on the radius at entry of the rotary section. The above-mentioned data were highlighted in the maps provided by NHAI.

Measurement of Rotary and Channelising Island:

View of the fact that Nanthoor is a busy intersection, it was a challenging task to perform the survey. Prior permission was taken from the NHAI as well as the police officers present at Nanthoor intersection to carry out the survey. The measurement of the central island, the channelizing island and width of the carriage way was done with the help of measuring tapes. Survey was done at Nanthoor intersection on February 08, 2021 (11:30PM-1:30AM) to measure the width of the central island, the channelizing island and width of the carriage way.

A second survey was carried out on February 12, 2021 (12:00AM-1:30AM) to measure the width at entry, width of non-weaving section, width of weaving section and weaving length.

Calculation of Capacity of Rotary using measured values:

The collected data were assembled and a sectional plan was drawn to calculate the practical Capacity of Nanthoor intersection using war drop’s formula. Further, a study was done to find the practical capacity of the weaving section of the rotary in PCU per hour as per the Indian Road Congress. War drop’s formula was used to calculate the practical capacity of rotary using the values obtained by manual survey performed at Nanthoor intersection.

$$Q_P = \frac{280 \times w \times \left[1+\frac{e}{w}\right]\left[1-\frac{P}{3}\right]}{1+\frac{w}{l}}$$

design speed = 30km/h

w = width of weaving section

l= length in meters between 2 channelising islands

e = average entry width of rotary

$$e = \frac{e_x + e_y}{2}$$

P = proportion of weaving traffic

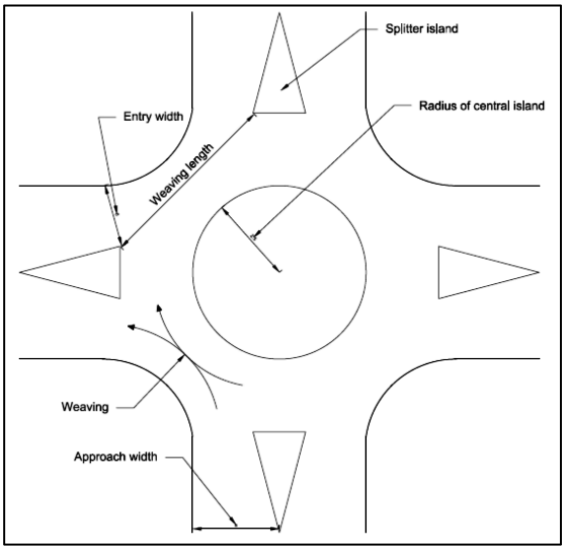

Fig. 5: General Diagram of Roundabout.

Design Rotary as per IRC: 65:1976:

According to the guidelines provided by IRC: 65:1976, a standard set of values have been specified for the design of the practical capacity of the rotary intersection.

As per the IRC: 65:1976 the practical capacity of the rotary intersection is carried out using the wardrop’s formula:

$$Q_P = \frac{280 \times w \times \left[1+\frac{e}{w}\right]\left[1-\frac{P}{3}\right]}{1+\frac{w}{l}}$$

By assuming the design speed as 30km/h

Q_P = practical capacity of the weaving section of the rotary in PCU

w = width of weaving section

w = the width of the weaving section should be one traffic lane (3.5m) wider than the mean entry width.

$w = \frac{e_x + e_y}{2} + 3.5$

l = the weaving length is achieved by making the ratio of the weaving length to the weaving width. A ratio of 4:1 is regarded as minimum.

l = 30m (minimum), for 30km/h

e = average entry width of rotary

$$e = \frac{e_x + e_y}{2}$$

e_x = width of carriage way at entry

e_y = width of non-weaving section

P = proportion of weaving traffic

$$P = \frac{b+c}{a+b+c+d}$$

V. RESULTS AND CONCLUSION

Observation:

The preliminary site investigation revealed that the congestion occurred due to halt/decrease in speed of vehicles transiting towards the weaving section leading towards Moodbidri. It was found that the signal system at intersection of Nanthoor were inoperative, thus controlling of traffic lanes at the intersection were done by traffic police which could be less accurate as compared to automated signal systems. Further, the delay in movement of vehicles was found to be transpired at all the weaving section due to undetailed design of rotary and hence an attempt is made in re-designing the Rotary with the intention of increasing the capacity of Rotary.

Calculation of Capacity of Rotary using measured values:

Using wardrop's formula the practical capacity of Nanthoor intersection is carried out:

$$Q_P = \frac{280 \times w \times \left[1 + \frac{e}{w}\right]\left[1 - \frac{P}{3}\right]}{1 + \frac{w}{l}}$$

Q_P = practical capacity of the weaving section of the rotary in PCU

w = width of weaving section

l= length in meters between 2 channelising islands

e = average entry width of rotary

$$e = \frac{e_x + e_y}{2}$$

P = proportion of weaving traffic

According to the survey conducted at Nanthoor intersection the following data were collected:

$w1$ = 22.6m, w 2 = 14.5m, w 3 = 28m, w 4 = 21.4m

$l1$ = 39.3m, $l2$ = 38.6m, $l3$ = 18.5m, $l4$ = 24.6m

e_{11}= 13.1m, e_{12}= 12.3m, e_{13}= 12.4m, e_{14}= 9.47m

e_{21}= 18.8m, e_{22}= 18.7m, e_{23}= 18m, e_{24}= 18.5m

$$e = \frac{e_1 + e_2}{2}$$

e_1 = 15.95m, e_2 = 15.5m, e_3 = 15.2m, e_4 = 13.985m

$$P_1 = \frac{1443 + 807 + 1002 + 375}{1443 + 807 + 1002 + 375 + 2181 + 427}$$

$P_1 = 0.582$

$$P_2 = \frac{2254 + 375 + 2556 + 807}{2254 + 375 + 2556 + 807 + 245 + 1224}$$

$P_2 = 0.803$

$$P_3 = \frac{1443 + 427 + 2556 + 1224}{1443 + 427 + 2556 + 1224 + 807 + 474}$$

$P_3 = 0.815$

$$P_4 = \frac{2254 + 1224 + 427 + 1002}{2254 + 1224 + 427 + 1002 + 375 + 1550}$$

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$P_4 = 0.718$

P1 = 0.582, P2 = 0.803, P3 = 0.815, P4 = 0.718

1 – Mangalore, 2 – Udupi,
3 – Moodbidri, 4 – Pumpwell

$$Q_{P_1} = \frac{280 \times 22.6 \times \left[1 + \frac{15.95}{22.6}\right]\left[1 - \frac{0.582}{3}\right]}{1 + \frac{22.6}{39.3}}$$

$Q_{P_1} = 5524$ PCU (Entering from Mangalore)

$$Q_{P_2} = \frac{280 \times 14.5 \times \left[1 + \frac{15.5}{14.5}\right]\left[1 - \frac{0.803}{3}\right]}{1 + \frac{14.5}{38.6}}$$

$Q_{P_2} = 4472$ PCU (Entering from Udupi)

$$Q_{P_3} = \frac{280 \times 28 \times \left[1 + \frac{15.2}{28}\right]\left[1 - \frac{0.815}{3}\right]}{1 + \frac{28}{18.5}}$$

$Q_{P_3} = 3505$ PCU (Entering from Moodbidri)

$$Q_{P_4} = \frac{280 \times 21.4 \times \left[1 + \frac{13.985}{21.4}\right]\left[1 - \frac{0.718}{3}\right]}{1 + \frac{21.4}{24.6}}$$

$Q_{P_4} = 4030$ PCU (Entering from Pumpwell)

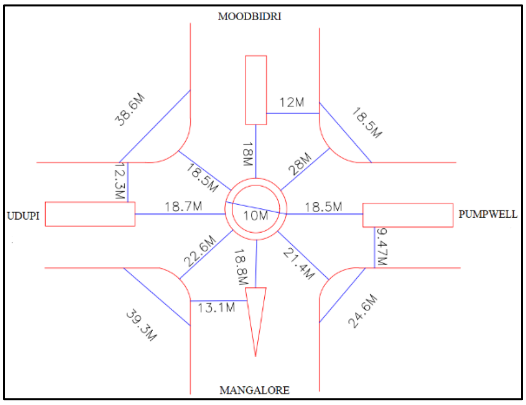

Fig 6: Actual Design of Nanthoor Intersection

Design Rotary as per IRC: 65:1976:

Considering the Practical capacity of rotary in the existing intersection to be less, an attempt has been made to redesign the traffic rotary at Nanthoor junction as per IRC 65:1976 guidelines for urban road with an objective of increasing capacity of rotary using Wardrop’s formula we calculate the practical capacity:

$$Q_P = \frac{280 \times w \times \left[1 + \frac{e}{w}\right]\left[1 - \frac{P}{3}\right]}{1 + \frac{w}{l}}$$

Q_P = practical capacity of the weaving section of the rotary in PCU

Assuming Design speed = 30km/h

Keeping the radius of central island same as that of the actual rotary,

e = average entry width of rotary

$$e = \frac{e_x + e_y}{2}$$

e_x = width of carriage way at entry

e_y = width of non-weaving section

Assuming $e_1 = 12$m, $e_2 = 17$m

$$e = \frac{12 + 17}{2}$$

$e = 14.5$m

w = width of weaving section

w = the width of the weaving section should be one traffic lane (3.5m) wider than the mean entry width.

$$w = \frac{e_x + e_y}{2} + 3.5$$

$$w = \frac{12+17}{2} + 3.5$$

$w = 18$m

l = the weaving length is achieved by making the ratio of the weaving length to the weaving width. A ratio of 4:1 is regarded as minimum.

$l = 30$m (minimum), for 30km/h

$l = 4 \times w$

$l = 72$m

P = proportion of weaving traffic

$$P = \frac{b+c}{a+b+c+d}$$

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$$P_1 = \frac{1443 + 807 + 1002 + 375}{1443 + 807 + 1002 + 375 + 2181 + 427}$$

$$P_1 = 0.582$$

$$P_2 = \frac{2254 + 375 + 2556 + 807}{2254 + 375 + 2556 + 807 + 245 + 1224}$$

$$P_2 = 0.803$$

$$P_3 = \frac{1443 + 427 + 2556 + 1224}{1443 + 427 + 2556 + 1224 + 807 + 474}$$

$$P_3 = 0.815$$

$$P_4 = \frac{2254 + 1224 + 427 + 1002}{2254 + 1224 + 427 + 1002 + 375 + 1550}$$

$$P_4 = 0.718$$

$$Q_{P_1} = \frac{280 \times 18 \times \left[1 + \frac{14.5}{18}\right]\left[1 - \frac{0.582}{3}\right]}{1 + \frac{18}{72}}$$

$Q_{P_1} = 5867$ PCU (Entering from Mangalore)

$$Q_{P_2} = \frac{280 \times 18 \times \left[1 + \frac{14.5}{18}\right]\left[1 - \frac{0.803}{3}\right]}{1 + \frac{18}{72}}$$

$Q_{P_2} = 5331$ PCU (Entering from Udupi)

$$Q_{P_3} = \frac{280 \times 18 \times \left[1 + \frac{14.5}{18}\right]\left[1 - \frac{0.815}{3}\right]}{1 + \frac{18}{72}}$$

$Q_{P_3} = 5302$ PCU (Entering from Moodbidri)

$$Q_{P_4} = \frac{280 \times 18 \times \left[1 + \frac{14.5}{18}\right]\left[1 - \frac{0.718}{3}\right]}{1 + \frac{18}{72}}$$

$Q_{P_4} = 5537$ PCU (Entering from Pumpwell)

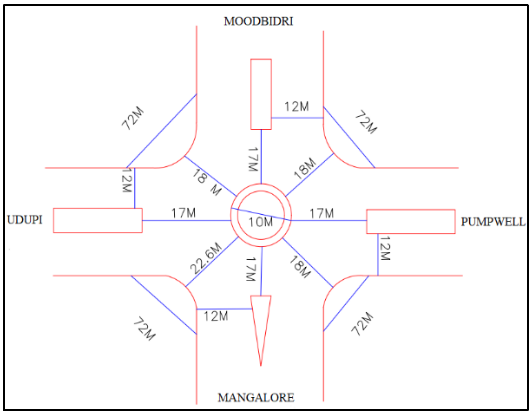

Fig 7: Design as per IRC: 65:1976.

Table 1 illustrating the Practical Capacity of Existing Rotary & Redesigned Practical Capacity of Rotary as per IRC

SL NO	ROUTE	PRACTICAL CAPACITY OF EXISTING ROTARY (PCU)	REDESIGNED PRACTICAL CAPACITY OF ROTARY AS PER IRC (PCU)
1	MANGALORE	5524	5867
2	UDUPI	4472	5331
3	MOODBIDRI	3505	5302
4	PUMPWELL	4030	5537

VI. CONCLUSION

- From the present study, it was found that the rotary at existing site of Nanthoor intersection was not functioning adequately due to abrupt growth of traffic and delayed traffic movement in the weaving section of rotary due to less accurate rotary design.

- The computations made from the present study proved that the practical capacity of the rotary could be increased by redesigning rotary.

- An attempt made to redesign the rotary of Nanthoor intersection as per IRC: 65:1976 has proven to have increased capacity when compared to existing intersection. However, in the process of redesigning, it was found that the length of weaving section had to be considered as 72m which was practically unacceptable due to inadequate space at the weaving section.

 ISBN: 978-93-90214-19-8

VII. REFERENCES

[1] Sitesh Kumar Singh and Karan Prabhakar, "Statistical analysis of traffic rotary Intersection", ISSN: 2277-9655, 2017.

[2] Monusha chowdri N, Extent of road traffic accidents in Mangaluru city, Karnataka, India. J Forensic Sci & Criminal Inves. 2019; 11(3):555813.

[3] K P Deepdarshan, Blackspot at Mangaluru city, Karnataka, India. Dept. of Civil Engg., Wollega University, Ethiopia; 2010.

[4] Ishanya P, "Study on Rotary Intersection at Mangaluru – Case study of Nanthoor Junction", ISSN:2393-8374, Vol.4, Issue 5, 2017.

[5] Surrender Kadyan and V K Ahuja, "A Study of Rotary Intersection at Panipat", IJERST&E, ISSN: 2319-7463, Vol. 5 Issue 7, July-2016.

[6] Kadiyali L R, "Traffic Engineering and Transportation Planning", Khanna Publications, New Delhi, pp 45-63, 251-264, 342-348,2016.

[7] Indian Road Congress, "Recommended Practice for Traffic Rotaries", IRC 65:1976, New Delhi,1976.

Development of Computer Program for determination of Along Wind Load on Tall Buildings

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Abstract— India is the second largest country after China in population with the current population is approximately 1,388,678,977. Increase in population creates the lack of spaces in urban areas. Urbanization development with continuous increase in population creates the need of construction of tall slender residential buildings. The increasing number of taller buildings planned and constructed in the country makes the wind analysis necessary under wind loads. The present Indian Standard of practice IS 875 (Part 3) – 2015 gives simple and systematic procedure to determine along as well as across wind response of building with use of formulae. The systematic set of formulae ideally suited for manual calculation as well as computer programming. The paper discusses the development of Computer Program in Microsoft Excel 2010 for determination of along wind response of tall buildings as per present Indian code of practice. Buildings of height 60m, 80m and 90m have been analyzed manually and using computer program.

Index Terms—*IS 875 (Part 3):2015, Along Wind Load, Computer Program*.

I. INTRODUCTION

Construction of Tall slender multistoried buildings in both developed and developing countries is very popular nowadays due to increase in population and lack of space. Tall slender buildings are slender flexible in nature. The analysis of such structures is necessary with special emphasis on the dynamic response of building on wind pressures. Investigation to ascertain wind induced along and across oscillations of the building is important.

The procedure to predict wind induced oscillations is given in present Indian code of practice, IS 875 Part 3: 2015. The code discusses stepwise procedure to predict along as well as across wind loads. The procedure includes the use of simple formulae to calculate the wind pressure, gust factor, shear force and bending moment variation at various decided level for a particular tall slender building.

Wind tunnel experimentation is the main source of knowledge to predict wind loads on tall structures.

The paper discusses the development of computer program based on the present Indian code of practice to determination of wind pressure, gust factor, shear force and bending moment for a tall building of height of 60 m in terrain category 1. The program is developed in Microsoft Excel 2010 to determine the wind induced parameters. The validation of computer program is also included.

Aim behind developing a computer program to save the time and avoids the expensive wind tunnel experimentation. The program also helps in reducing the manual calculations for wind analysis for any tall buildings.

II. ILLUSTRATIVE EXAMPLE

A slender multistoried building 20 m long and 30 m wide is 60 m high as shown in Fig. 2.1 below. The building is located in a region where basic wind speed is 50 m/s and terrain category 1. Determine the wind load & Moments on the building as per IS 875 (Part 3) – 2015 and validate the results using computer program.

 ISBN: 978-93-90214-19-8

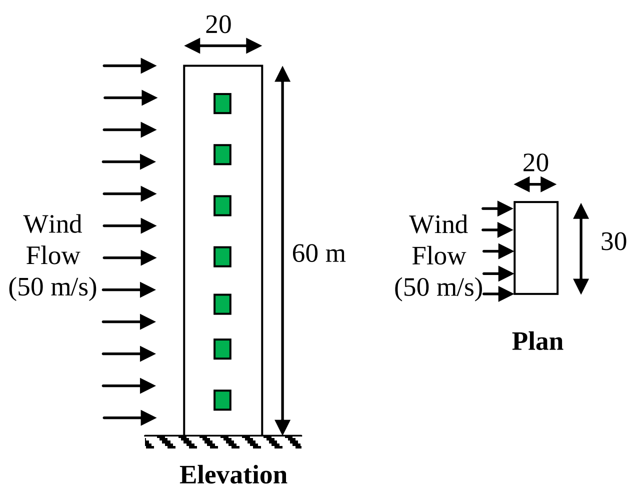


Fig. 2.1

Design peak along wind load on the building at any height z, (as per clause 10.2, page no. 47)

$F_z = C_{f,z} A_z \bar{p}_d G$

At height 10m, (for example)

$F_z = 1.30 \times 10 \times 30 \times 1342.37 \times 1.914 = 1001.94\ kN$

Following table 2.1 and 2.2 shows results are obtained by analyzing the given building manually as per IS 875 (Part 3):2015.

Table 2.1 Results after Manual Calculations

Level (m)	Wind Speed (V_b) (m/s)	$k_{2,i}$	Gust Factor (G)	Design Wind Speed $V_{z,d}$ (m/s)
60	50	0.946	1.914	47.30
50	50	0.929	1.885	46.45
40	50	0.908	1.858	45.40
30	50	0.882	1.826	44.10
20	50	0.845	1.814	42.25
10	50	0.782	1.798	39.10
0	50	0	1.787	0

Table 2.2 SF and BM Variation

Level (m)	Design Wind Pressure p_d (N/m^2)	Design Wind Force, F_z (kN)	Shear Force (kN)	Bending Moment (kNm)
60	1342.37	1002	1002	0
50	1294.56	952	1954	10020
40	1236.69	896	2850	29560
30	1166.88	831	3681	58060
20	1071.04	758	4439	94870
10	917.28	643	5082	139260
0	0	0	5082	190080

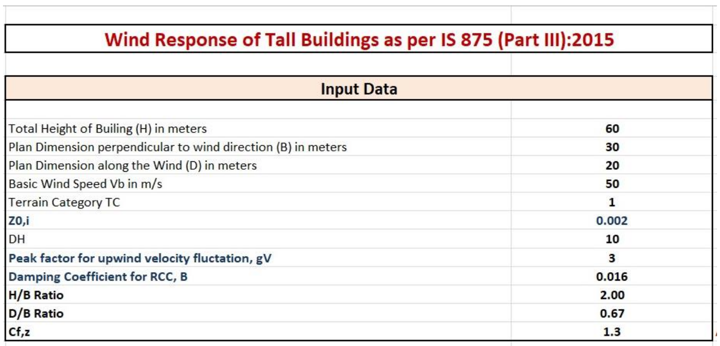
The given building is divided into 6 levels having height of each level as 10m. At each level calculation of wind pressure, gust factor, design wind speed, shear force and bending moment is done and tabulated in table 2.1 and 2.2.

III. DEVELOPMENT OF COMPUTER PROGRAM

A computer program is prepared on Microsoft Excel platform with the formulation provided for Along Wind Response in IS 875 (Part 3):2015.

Input Parameters:

1. Total Height of Building (H) in meters
2. Plan Dimension perpendicular to wind direction (B) in meters
3. Plan Dimension along the Wind (D) in meters
4. Basic Wind Speed Vb in m/s
5. Terrain Category TC
6. Drag Force Coefficient, C_f



Wind Response of Tall Buildings as per IS 875 (Part III):2015

Input Data	
Total Height of Builing (H) in meters	60
Plan Dimension perpendicular to wind direction (B) in meters	30
Plan Dimension along the Wind (D) in meters	20
Basic Wind Speed Vb in m/s	50
Terrain Category TC	1
Z0,i	0.002
DH	10
Peak factor for upwind velocity fluctation, gV	3
Damping Coefficient for RCC, B	0.016
H/B Ratio	2.00
D/B Ratio	0.67
Cf,z	1.3

Fig. 3.1 Input for the program

Output of the Program:

At each decided level, the program gives the following output result and also plots the shear force and bending moment values.

1. Wind Pressure

2. Along Wind Force
3. Gust factor
4. Shear Force
5. Bending Moment

Table 3.1 Output of Program

Level	Fz	SF	BM
	kN	kN	kNm
60	1005.03	1005	0
50	955.77	1961	10050
40	900.89	2862	29658
30	837.79	3699	58275
20	759.53	4459	95270
10	643.33	5102	139860
0	0	5102	190883

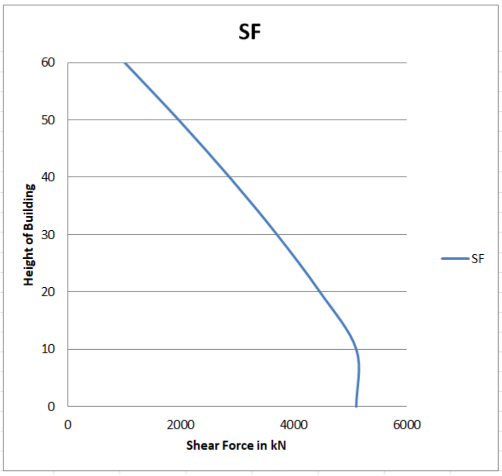


Fig. 3.2 program output for Shear force

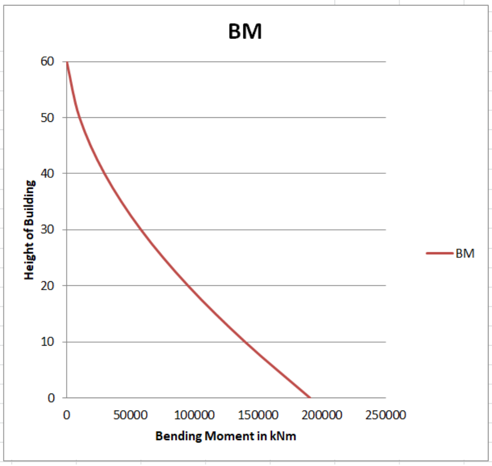


Fig. 3.3 program output for bending moment

IV. Validation of Computer Program

Figures 4.1 and 4.2 shows shear force and bending moment variation at various levels and their validation.

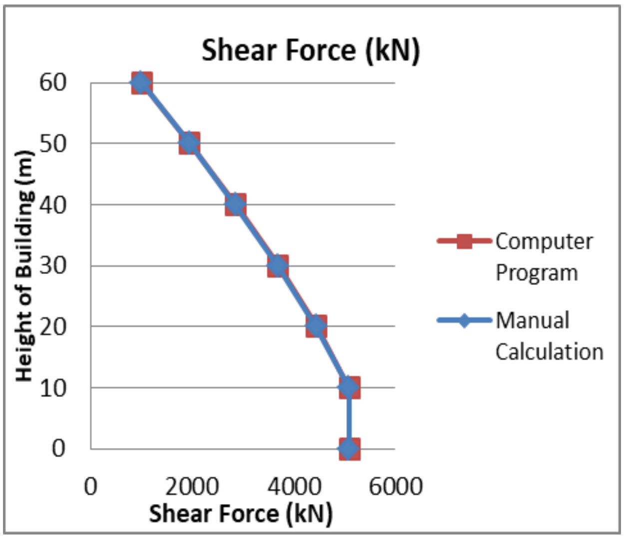


Fig. 4.1 validation of Shear force

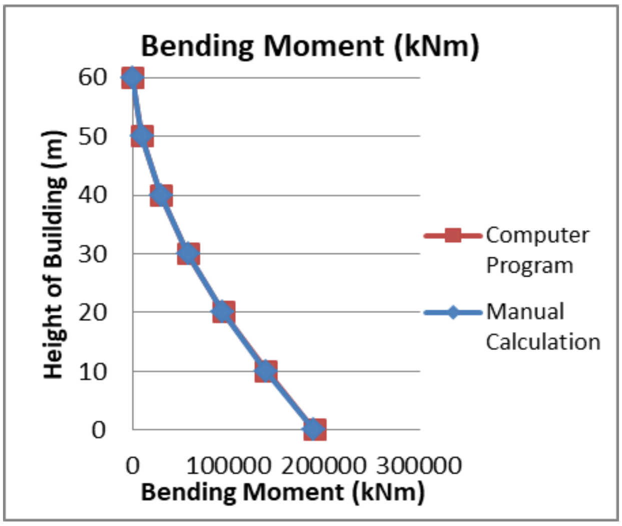


Fig. 4.2 Validation of Bending moments

Conclusion

1. From the Shear force and bending moment variation shown in Figure 4.1 and 4.2, it is clearly seen that the validation of the computer program is successful.
2. The buildings with different cross sectional parameters in terrain category 1 and 2 can be analyzed using computer program.
3. Time for manual calculations, wind tunnel experimentation and cost can be minimized by the use of computer program.

REFERENCES

[1] Suyog Dhote, Valsson Varghese, "Wind Response of Tall Buildings using Indian and Australian Standards", SSRN Proceedings of Sustainable Infrastructure development and Management (SIDM 2019), VNIT, Nagpur, 22-23 Feb 2019.

[2] Suyog Dhote, Valsson Varghese, "Application of Artificial Neural Network in Wind Response of Tall Buildings", International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE), vol. 3, Issue 1, pp 164-167, January 2018.

[3] Suyog Dhote, Valsson Varghese, "Use of Artificial Neural Network in Wind Response of Tall Buildings", International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE), Vol 2, Issue 3, pp 434-437, March 2017.

[4] IS 875 (Part 3):2015, Design Loads (other than Earthquake) for buildings and structures – code of practice, Bureau of Indian Standards, New Delhi.

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 ISBN: 978-93-90214-19-8

Study of Traditional Wada Structure Approach to Improve Modern Buildings from Point of Planning, Sustainability and Energy Efficiency

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***Abstract*— Wadas are a rich and cherished architectural heritage in Maharashtra, reflecting the pride, religion, culture, traditions and turbulent history of marathas. The architecture of Maharashtra dates back to 17th and 18th century with high architectural and cultural significance. During the 16th and 17th century, after the establishment of power of peshwas in Maharashtra, several small and medium and palatial scale traditional dwelling of particular style came into existence. This created a new architectural dictionary, which enhanced the lifestyle of people.**

A RCC building are the main structural members of building viz, slabs, beams, columns and foundations are made up of reinforced cement concrete. Yet wadas form the root to culture, social and behavioral pattern to the present. The study will interpret the two different residential topologies the one which is traditionally build and other is modern residence. Traditional building seems to have lost its relevance in today's world due to change in lifestyle and economizing of spaces. This paper describes study of traditional wada structure. The study investigates two different types of buildings viz wada and RCC building. It provides knowledge about the planning of wada and arrangements of elements of dwelling according to their purpose. The study consists of aspects such as external privacy, thermal insulation, acoustical conditions. Study of traditional wada structure in approach with improvement of modern buildings in point of view of planning, sustainability and energy efficiency.

This study will help in increasing awareness amongst contemporary designers to integrate traditional architecture embodied in today's practices.

***Index Terms*— energy efficiency, modern dwelling, planning, privacy, sustainability, wada**

I. INTRODUCTION

Understanding the changes over the period of time has significant part of vernacular architecture. The factors responsible for changes consists of social, cultural, economic and political changes. Multidisciplinary analysis of architectural form is a better approach to study transformations. Vernacular architecture needs to be addressed by anthropology, history, archaeology, geography. Research concerned with the changes occurred and the way they happened. Wada has been considered as a vernacular architecture while studying. Wadas- which were the traditional residential form of Maratha architecture evolved under the region of peshwas. It was wholly introvert arrangement of rooms and veranda around courtyards. The provision of courtyard open to the sky within ensured plenty of light and ventilation without sacrificing privacy. It is transition space between public and private part of dwelling. No. of courtyards in wada depicts status of the family. Osari is the semi open space verandas surrounding area between the courtyard. Diwan khana is the huge living room for formal meetings. Devghar is a prayer room. Majghar is a middle room which divides public area and private area. Kothar is a store for grains. RCC is nothing but the reinforced cement concrete in which cement concrete is reinforced with steel bars. As the concrete is strong in compression but weak in tension, steel bars are used along with concrete to increase the strength of the structure. In RCC structure, load is transferred from slab to beams, beams to columns, columns to foundation and which in turns transfers to the soils. After construction of frames, walls in the structures are constructed. The RCC buildings are constructed considering architectural planning principles.

2. SITE STUDY

Site study 1- Patil wada, Padali

 ISBN: 978-93-90214-19-8

Fig 1: Façade of Patil Wada

The wada is situated at Padali which is recently built in 2010 by Mr. Bhanudas Patil. The wada received the attraction from local area. Construction area of Wada is around 300 sq. ft. having two floors with only one entrance to the dwelling. Wada has both front yard and backyard. Entry door opening height is 7.4 ft., length 4 ft., panel thickness 0.11m. Passage width is 4.5 ft. Mangalore tiles are used for flooring having dimension 2ftx2ft.Internal wall thickness is 0.53 m. Circular columns of diameter 2 m. Exit passage width is 5 ft.

Dog legged staircase having 0.15 m riser and 0.35 m trade. The wada has pitched roof having wooden battens. The tiles which are provided having size 2ftx2ft. temperature inside the wada is 26˚c and outer temperature is 27˚c. Sound intensity inside the wada is nearly 47Hz and outside is 57Hz.

Fig 2: Courtyard

Fig 3: Mangalore tiles roofing with truss

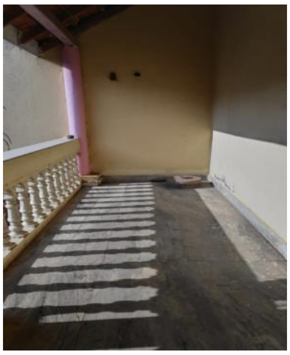

Fig 4: Osari/ Verandah

Fig 5: Entry to the courtyard

Site study 2- Suryawanshi wada, Yelur

Fig 6: Façade of Suryawanshi Wada

Suryawanshi wada is located in Yelur, Sangli constructed before nearly 100 years for 4 families. Current owner of the wada is Subhashrao Gunawantrao Suryawanshi. The wada having two floors with one main entrance. Floor to floor height is 8 m (2 floors). External wall thickness is 1.2 m and internal wall thickness is 0.82 m.

Column and beam are of sizes 20m x20m. Dog legged staircase having riser 0.28m and trade 0.3m. Entry steps having 0.28m riser and 0.30m trade. Temperature inside the wada is 28˚c and external temperature is 25˚c. Sound intensity inside the wada is nearly 60 Hz and outside is 73 Hz.

Fig 7: Members of Suryawanshi Wada

Fig 8: Courtyard

Fig 9: Osari/ Verandah

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Fig 10: Curtailment

Fig. 11 wall Niche

Fig 13: wooden doors

Fig 14: Wall niche

Fig. 12 one of the staircases

Fig 13. Wooden column with Stone support

Fig 11: Curtailment

Fig 12: one of the staircase

Site study 3- Kore wada, Yelur

Fig 10: Façade of Kore Wada

The wada is located at Yelur which was built before 200 years. The owner of the wada is Sanjay Ramchandra Kore. The wada having three floors with one main entrance. Floor to floor height is 2.5m per floor. External wall thickness is 0.75 m and internal wall thickness is 1.1 m. opening of door is of size 1.2mx2.5m. beams of size 0.25mx0.25m.

Dog legged staircase having 0.25m riser and 0.21m trade. Internal temperature of wada is 22˚c and external temperature is 27˚c. Sound intensity inside the wada is nearly 54 Hz and outside is 73 Hz.

Fig 13: Well

Fig 14: Courtyard

3. PLANNING ASPECTS:

- Planning is based on the local conditions and cultural factors such as weather, availability of local material etc.
- Wadas planned for number of families not on the basis of nuclear families.
- wada may have one or more courtyards surrounded by rooms with different functions. Different courtyards may serve different functions like social gatherings, official meetings called Kacheri, festival celebrations. Some courtyard may contain Tulsi plant for prayer purpose. Some courtyard may have well or Hauds for water storage.
- Generally zoning pattern in planning can be seen

ISBN: 978-93-90214-19-8

where public, private and semi-private zones can distinctively identified. Open to sky Courtyard comes under public zone, verhadah or Osari around courtyard is semi private zone followed by built area of wada.

- Wada have one or more dark and staircases sandwiched between two thick walls for privacy purpose.
- Wadas may contain fewer exterior openings thus open to sky courtyard serves the purpose of ventilation and lightening without sacrificing privacy.
- The scale of wada is dictated by the permutation and choice of elements such as Verandah, staircase, steps, well, pond/Haud, Tulsi vrindavan, Garden of plants and flowering shrubs.

4. USE OF MATERIAL AND CONSTRUCTION TECHNIQUES:

Wadas:

- Basalt stone is used up to plinth level. Uniform stone blocks are used for walls and flooring. Combination of wood and stone are used for columns in which wooden pillar with stone support can be seen. Timber is used as structural member for column, beams, trusses and brackets etc. Wooden brackets used at various places are highly craved for aesthetics.
- Clay tiles (mainly terracotta or country tiles) are used for the roof of wada. Timber rafters placed for the prevention of cracks.
- For plastering mud, cow dung or stone slab is used. The smooth lime plaster was made up of lime, jaggery, clay and wheat chaff for binding; the same mixture is used for exterior plastering. Also, smooth and sticky paste of gum from different trees is mixed with wet clay used for plastering.
- For windows and doors wooden battens are used.
- Staircase is made with stone blocks or wood.

RCC buildings:

- For RCC buildings burnt bricks are used for wall construction. Maybe there is use of decorative stone for aesthetics.
- RCC elements such columns, beams slab uses concrete with reinforcement. Various grades of concrete are used based on the building load. Cement, sand, gravel and water in well propositioned quantities are used as concrete. Concrete has very high compressive strength and to increase the tensile strength reinforcement is done.
- Depending upon activities in the concrete mix admixtures can be used as accelerators, retarders, air entraining agents.
- For doors and windows aluminon, glass, wood can be seen.
- For formwork wood, timber, steel etc are used.

5. ENERGY EFFICIENCY AND SUSTANABILITY:

- Wada is load bearing structure built using materials which are locally available like timber, wood, stone and many more. There locally available materials are easily found and it consumes less energy and cost for transportation and production.
- Different rooms in wada are skillfully planned according to the elements like sun, wind, rain patterns which provides protection and ability to withstand climate differences.
- Intelligent use of bulling materials and natural resources in structure gives more comfort and sustainable living.
- Plastering and timber used in wada structure are acts as thermal insulator increases energy efficiency.
- Strategic planning of structure provides protection from direct sunlight. Heated air gets cooled in osari before entering the rooms keeping the other portion of house cool. Such use of natural lighting and ventilation make it more energy efficient.

CONCLUSION

Wada architecture is great source of inspiration for today's engineer in order to achieve energy efficient and sustainable structure.

For improving modern structure constructure following guidelines can be adopted:

1. Considering natural parameters such as sun, wind, local rain pattern for the arrangement for components of the building. So as to achieve maximum benefits from surrounding nature like ventilation and lighting and protect the structure from weather variations.
2. For the construction use maximum amount locally available materials and workers to reduce the energy and cost. Also select the materials which have less impacts on environment and can easily available.
3. Building plan, number of components, arrangement of the components should be based on need and financial status of occupants.
4. Building should be designed such it will consume a smaller number of new sources of materials and at the end of its life should be source for new structure to be build.
5. Components of building should be flexible to serve many functions.
6. Adopt easy and practical solutions for issues like secrecy, security and comfort living.

ISBN: 978-93-90214-19-8

REFERENCES

[1] Study of Traditional Approach towards Contemporary Design:
Sushma S. Dhepe, Dr. Sheeba Valsson Associate professor, B.V.D.U College of Architecture, Pune Principal, Shri Datta Meghe College of Architecture

[2] Roopal Deshpande and Rajashree Kotharkar (Visvesvaraya National Institute of Technology, Nagpur, India) "'Dwellings' then and now: A topological approach for privacy analysis of 'Wada' and modern House."

[3] Peter O. Akadiri , Ezekiel A. Chinyio and Paul O. Olomolaiye .(2012) " Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector." - 2012

[4] Narendra Dengle "The Introvert and the Extrovert Aspects of the Marathi House."

[5] Spatial Form Analysis and Sustainable Development Research of Traditional Residential Buildings. Hai-fan Wang and Shang-chia Chiou -2020

[6] Preservation of Maharashtrian cultural heritage, Anushari Kulkarni

[7] Sustainable Features of Vernacular Architecture: Rural Housing at Kelshi, Maharashtra As Case Study
Gauri Ashok Kamble, Dr. Parag Govardhan Narkhede

[8] Amir Ghiasi, The Relationship And Role Of Vernacular Architecture In Achieving And Manifesting Sustainable Architecture

[9] Rejuvenating the Vernacular Architecture of South India as the representative of Sustainable Architecture: a case study of Hubli, Karnataka Dr. K.Thirumaran, Deepti Shankar Hegde

[10] Eco Friendly materials used in traditional buildings of Chettinadu in Tamil Nadu, India, S. Radhakrishnan, R. Shanthi Priya

[11] A Comparative Study of Transformations in Traditional House Form: The Case of Nagpur Region, India, Rajashree Kotharkar, Roopal Deshpande

Study on Replacement of Cement by Industrial Waste and Agricultural Waste

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Abstract* — High demand of natural resources because of rapid urbanization gives the high amount of production of Indo-Agricultural waste. Many materials from Indo-Agricultural waste are used as a replacement of cement, sand, fine aggregate, coarse aggregate and reinforcement. The aim of this paper is to use of the indo-agricultural waste in construction as a replacement of cement during a varying proportion. This work investigates the effect of Rice Husk Ash(RHA), and Ground Granulated furnace Slag(GGBS) as a partial replacement of cement. Nowadays, various quite waste aren't having any industrial applications. So, it's easy to use this waste as a staple within the engineering field to cut back the use of concrete worldwide. we are going to use these wastes because the non-conventional and reuse or recycling of waste to compensate the shortage of the natural resources. So, wastes are openly used to produce new products or are often used as admixtures within the engineering field. So these material cause disposal crises and thereby contributing to the environment problems, the use of waste materials in concrete may give the safe and economical disposal of waste materials. Generally, the wastes contain the pozzolonic property of fineness and plasticity. So, it increases the strength of the materials. Due to the availability of the pozzolonic characteristics in waste, it may partially replace the materials and known benefits on the durability of the products. Under this, the wastes are partially replaced by 53 grade of cement in M25 grade of concrete mix and tests were conducted for various proportions to research or find the strength attainments (compressive) tests are followed under the standard setup procedures and machines.

Keywords: Partial Replacement, Rice Husk Ash(RHA), Ground Granulated Blast Furnace Slag(GGBS), Cement, Coarse Aggregate, Fine Aggregate, water.

I. INTRODUCTION

In India, on the daily basis 1.50 Lakh metric ton of solid waste produced (According to a 2019 India Today Report) from which only 20% i.e. 27,000 MT per day is processed for recycling or reuse or reduce process and the remaining 80% i.e. 1,08,000 MT per day is dumped in landfill sites. The waste may includes Municipal Solid waste, Hazardous waste, Industrial waste, Agricultural waste, Bio-Medical waste, Waste Minimization, etc. Out of the above the Industrial waste and Agricultural waste are used for replacement of cement partially.

➢ Industrial waste:

- The waste material produced by industries or by industrial processes, is called Industrial Waste. Industrial waste includes chemicals, trash, gravels, oils, dirt & many harmful gases, etc. These waste have been dumped in seas, river sides or on land without proper treatment. Thus, it produces a large amount of Environmental Pollution.
- Industrial waste is more toxic and it requires special treatment.
- There are 2 types of Industrial Waste:

01. Biodegradable Industrial Waste: Those waste which can be decomposed and form unharmful substances after the action of microorganisms are called as Biodegradable wastes. There are many industries which produce Biodegradable Industrial waste such as Paper industry, Sugar industry, Food industry, wool industry, etc. The degradation of those waste can be done at low cost and easily.

02. Non-Biodegradable Industrial Waste: Those waste which can't be further degrade via applying the microorganisms and are called as Non-Biodegradable Industrial waste. Those Non-Biodegradable Industrial waste requires a large amount of space for landfills from chemicals, metals, plastics, paints, rubber, etc. these Non-Biodegradable waste remains as landfills for thousands of year without any damage.

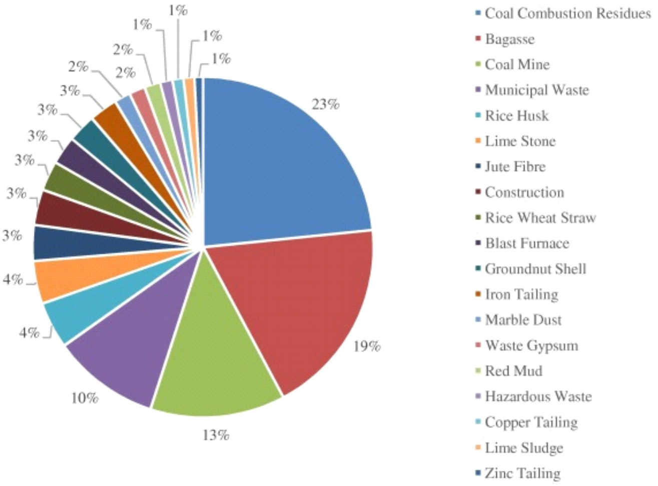
➢ Agricultural Waste:

- The Agricultural waste produced as a result of various agricultural operations. The Agricultural waste may include manure, waste from farm, poultry houses, slaughterhouses, harvest waste, fertilizers run off from fields, pesticides that enter into water and salt and slit drained from fields, etc.

- Increasing the population requires the greater amount of Agricultural Production. Agricultural production in the last five years has been increased more than three times and other factors responsible for increasing of agricultural production includes advancement in technology.
- At many sections in developing countries, agricultural waste were indiscriminately dumped or burned at public place and responsible for production of air pollution, soil may get contaminated, produces a harmful gases, smoke and dust and the residue will passes through the channels into a water source and pollute the water and aquatic environment.

Thus the production of Industrial and Agricultural waste get increases day by day and there is a requirement to dispose, recycle or reuse it. The advancement in concrete technology gives us the way to find the solution for disposal of those waste. The partially replacement of the concrete material offers the less use of concrete material and the way to get disposal of the waste. The use of the waste gives the cost reduction, energy savings, superior products and help environment to reduce pollution.

Fig. (01)



II. OBJECTIVE & SCOPE

01. Determination of optimum Ground granulated blast furnace slag (GGBS) & rice husk ash (RHA) content on strength characteristics of concrete mix.

02. Determination of specific proportion of cement, ground granulated blast furnace slag & rice husk in concrete.

03. Determination of proportion of rice husk &ground granulated blast furnace slag used while mixing with cement.

04. To compare the performance of three different proportion of ground granulated blast furnace slag (GGBS) and rice husk ash in concrete mix.

Scope: Due to bulk availability of GGBS and rice husk around Nagpur, there is high scope of making concrete by replacing of specific proportion of cement. GGBS & rice husk added in varying percentage in concrete and tested it engineering and index properties. GGBS & rice husk can be combined with other traditional used materials like lime, gypsum & tested its engineering & index properties.

III. EXPERIMENTAL MATERIALS

A) Waste Materials Used

[01] Ground Granulated Blast Furnace Slag (GGBS): GGBS is obtained from quenching molten iron slag (by product of Iron & steel) from a blast furnace in water or steam, which produces a glassy, granular product which was later dried and ground into a fine powder. GGBS is highly cementious material and it contains large percentages of calcium silicates hydrates (CSH) which is a strength increasing compound and also it improves the strength, durability and appearance of the concrete. There are 2 major use of GGBS. To produce quality improved slag cement known as Portland Blast furnace Cement (PBFC) and to produce High-Slag Blast-Furnace Cement (HSBFC) with GGBS content varying from 30% to 70% and also used for production of ready-mixed or site-batched durable concrete.
GGBS Cement made concrete set more slowly than the concrete made with Ordinary Portland Cement, depending upon the amount of GGBS material used while making concrete in the cementitious materials. And also it continue to increase the strength over a longer period. GGBS undergoes lower heat of hydration and lower temperature rises, but it may affect construction schedules where quick setting is required.
According to IS 12089: 1987, we can use cement with 50% of replacement with GGBS for the concrete mix.

[02] Rice Husk Ash (RHA): Rice Husk Ash was obtained from AMJ Overseas, Nagpur, Maharashtra.

 ISBN: 978-93-90214-19-8

Fig. (02)

It is the outer covering of rice grains, after removal of the covering, it burns at a standard temperature to obtained the by product of Rice Husk Ash (RHA). After burning of rice husk there is no use of ash and it creates a large amount of pollution and also create a dumping problem. Because of low nutrition property of rice husk, it is unusable and does not have edibility yet in the few nations. Generally it is use in an electric power plant as a compiling techniques to reduce the dumping problem of rice husk ash. In ancient time the rice husk is used to make Pavements.

(The temples of the Batujaya Archaeological Site in Indonesia (5th century AD) were built with bricks containing rice hulls.)

The more it burn, the more will be the percentage of Silicate. It was proved that RHA has a high pozzolanic property. It also helps to improve Compressive Strength and other mechanical properties also resist concrete from chloride attack.

B) Other Materials Used in Construction

[01] Cement (OPC): The Ordinary Portland Cement of 53 grade is being used to make concrete. It is having as Specific Gravity of 3.12 and consistency of 35%. Initial and Final setting time of 30 minutes (Minimum) & 600 minutes of (Maximum). (As per IS: 8112-1989)

[02] Fine Aggregate: The sand particles which passes from 4.75mm sieves to 150 microns are termed as Fine Aggregates. Mainly, the river sand is used with combination as fine aggregates. As a result, it fulfill the requirements of IS: 383. The river sand is washed and screen, just to eliminate the deleterious materials and oversize particles.

[03] Coarse Aggregate: The aggregates passes from 20 mm sieve and retained at 4.75 mm sieve are used as a Coarse Aggregates. The Coarse Aggregates are the one which was crushed from Basalt rock and are complete the requirements of IS: 383. The Elongation and Flakiness properties were checked and maintained at a level of 15%.

[04] Water: Water is an important material use in concrete because it takes a part in chemical reaction with cement. And it helps to improve strength by forming cement gel. The quality and quantity of water are required to be checked carefully before applying.

Table I: PROPERTY OF AGGREGATES & WASTE MATERIAL USED

Property	Fine Aggregate	Coarse Aggregate	GGBS	RHA
Fineness	Passing through 3.5&retained 2.4	Passing through 7.12 &retained6.86	427 m^2/kg	Passing through 45 mm sieve
Specific Gravity	2.38	2.76	2.23	1.67
Bulk Density	1753	1741	1513	1256
Water Absorption (%)	1.20	1.83	Varying in % of replacement	7

IV. MIX DESIGN

A mix of M25 grade was designed as per Indian Standard Method and the same was used to prepare the test samples. The mix proportion is as follows:

Table II: MIX DESIGN FOR M25

ISBN: 978-93-90214-19-8

GRADE CONCRETE

	By Volume (m^3)
Cement	2.00
GGBS	-
RHA	-
Fine Aggregates	2.00
Coarse Aggregates	4.00
Water	1.00

V. EXPERIMENTAL INVESTIGATION

A) Test Specimen

A 150mm X 150mm X 150mm metal mold were used as a test specimen to determine the compressive strength of concrete for both cases i.e. for normal concrete & for Partially mixed Rice Husk Ash and Ground Granulated blast furnace slag concrete.

B) Experimental Setup

Table III: DESIGN MIX PROPORTION FOR VARIOUS CONCRETE MIX

Sr. No.	Concrete Type	OPC Cement replaced with Indo- Agricultural Waste
01.	A	Standard Concrete (0%)
02.	B	5% Replacement of Both
03.	C	10% Replacement of Both
04.	D	15% Replacement of Both
05.	E	20% Replacement of Both

Table IV: CONCRETE MIX DESIGN (M25) MIX PROPORTION

Sr. No.	Concrete Type	Concrete Design Mic Proportion					
		W/c Ratio	Cement	F. A.	C. A.	GGBS	RHA
01.	A	0.50%	2	2	4	-	-
02.	B	0.50%	1.8	2	4	0.1226	0.091
03.	C	0.50%	1.6	2	4	0.2452	0.182
04.	D	0.50%	1.4	2	4	0.3678	0.273
05.	E	0.50%	1.2	2	4	0.4905	0.364

C) Experimental Methodology

According to the concrete type(From Table III & IV) the material were sieved and weighted carefully. The materials were mixed thoroughly till it looks uniform in all the way.
The slump cone test were performed to check the workability of concrete mix.

After Slump Cone test 09 cubes samples were cast of M25 grade concrete mix with partially replacement of cement with a water/cement ratio as 0.5 which was also cast and compacted properly. All the cubes were de-molded within 24 hours after of casting. The de-molded cubes are curing properly in water available in the laboratory for the interval of 7, 14 and 28 days.

[Sample Calculation: For concrete type D (For 01 Cube) i.e. 15% replacement of GGBS and 15% replacement of RHA, we need 1.4Kg of Cement, 2Kg of Fine Aggregates,4Kg of Coarse Aggregates, 0.3678Kg of GGBS and 0.273Kg of RHA along with water/cement ratio of 0.50%]
(RHA & GGBS was taken according to the Specific Gravity of the material)

Table V: TOTAL NUMBER OF CUBES FOR VARYING PROPORTION

Replacement	0%	05%	10%	15%	20%
07 Days	03	03	03	03	03
14 Days	03	03	03	03	03
28 Days	03	03	03	03	03
Sub-Total =	**09**	**09**	**09**	**09**	**09**
Total =					**45**

There were total 45 nos. of cubes were casted and cured and checked the Compressive Strength of the cubes.

ISBN: 978-93-90214-19-8

VI. RESULT

The Compressive strength of the cubes specimen was checked on the Compressive testing machine available on the laboratory. The values shown on the table VI are the mean of three cubes of each percentage for 7, 14, 28 days of replacement. The result are tabulated as follows:

	0 %	5 %	10 %	15 %	20 %
07 Days	26.7	14.5	15.2	15.2	14.4
14 Days	28.8	14.8	16.4	17.9	15.8
28 Days	29.3	18.3	17.2	19.3	16.3

(All the values are in MPa)

VII. COST SAVING

Table VI: FOR PLANE CONCRETE

Material	Cost (Rs/Kg)
Cement (OPC 53 Grade)	7
Fine Aggregate	0.85
Coarse Aggregate	0.6
Cost of 9 cubes	Rs. 162.9/-

Table VIII: FOR CONCRETE MIX (M25)
(FOR CONCRETE MIX OF D GRADE)
(i.e. of 15 % replacement of each)

Material	Cost (Rs/Kg)
Cement (OPC 53 Grade)	7
Fine Aggregates	0.85
Coarse Aggregates	0.6
Ground Granulated Blast furnace Slag	2.8
Rice Husk Ash	0.5
Cost of 9 Cubes	Rs. 135.6/-

From the above table (VI & VII) we conclude that, the cost for concrete mix is less than that of original plane concrete. So for the larger project it save nearly 20% of total cost.

VIII. CONCLUSION

From the result of Experimental Investigation concludes that the waste material use i.e. GGBS & RHA can be use as a partial replacement for Cement. It is found that the replacement of 15 % of each GGBS & RHA gives maximum result in Compression Strength than the normal concrete. The result showed that the 30 % of replacement of cement by the Indo- Agricultural waste increases the strength as well as also reduces the cost of material.

Utilization of these waste in the field of construction can be a safe alternative solution for disposal of those waste.

The void ratio were decreases as the curing days were increases.

It is observed that, the combination of Ground Granulated Blast Furnace slag and Rice Husk ash will be more durable as compared to normal concrete.

IX. REFERENCES

1. "India trash bomb : 80% of 1.5 lakh MT daily garbage remains exposed, untreated" by India Today magzine published on 21st July 2019.

2. "6 Main Types of Solid Waste"by Puja Mondal

3. " Application of Agro-waste for sustainable construction material" by Madurwas M. V., Ralegaonkar R. V., Mandavgane S. A., published on 2013.

4. "Mechanical Properties and durability Assessment of rice husk ash Concrete Bio. System" by Mandandoust R., Ranjbar M. M., Hamed Ahmadi Moghadam H. A., Mousavi S. Y., published on 2011.

5. "Concrete using agro – waste as a fine aggregates for sustainable built environment " by Jnyanedra Kumar Prusty, Sanjaya Kumar Patro, S. S. Basarkar, published on 12 June 2016.

6. "Combine effect of Rice Husk Ash and fly Ash on concrete by 30 % cement replacement" by Satish H. Sathawane, Vikrant S. Vairagade, Kavita S. Kane, published on 2013.

7. "Use of waste material in concrete" by Davoud tavakoli, Masoumeh Hashempour, published on April 2018.

8. "Use of Rice Husk Ash as a Partial Replacement with Cement in concrete" by Sourav Ghosal, S. Moulik, published on 01 Sept. 2013.

9. "Sustainable Studies on concrete with GGBS as a replacement material in Cement" by S. Arivalagan, published on 03 November 2014.

10. "Use of Industrial & Agricultural Wastes in Construction Concrete" by Hasan Sahan Arel, Ertug Aydin, published on January 2018.

11. "Strength and workability Properties of GGBS and Rice Husk Ash" by Divya Bhavana Tadepalli, Madhavi Etaveni, Syed Eashan Adil, published on 2 march 2016.

12. "Strength development characteristics of concrete produced with blended cement using Ground Granulated Blast Furnace Slag under various curing Condition" by Shahab Samad, attaullah Shah, Mukesh Climbachiya , published on 07 July 2017.

13. "Study of Management and Control of Waste Construction Materials in Civil Construction Projects" by Karrar Raoof Kareem Kamoona, published on February 2016.

14. "Effect of Rice Husk Ash and GGBS on performance of Concrete" by B. N. Sangeetha, published on 12 December 2015.

15. "Ground Granulated Blast Furnace Slag (GGBS) in concrete" by D. Suresh, K. Nagaraju, Published on June 2015.

16. "Rice Husk Ash as a potential source Material for Geopolymer Concrete" by Shaswat Kumar Das, Syed Mustakim, Jyotirmoy Mishra, published onOctomber 2018.

17. "Construction Material From Industrial Wastes" by M. Ramesh. K.S. Karthic, T. Karthikeyan, A. Kumaravel, published on 04 November 2014.

18. "Use of Waste Material in the Construction Industry" by Ryszard Dachowski, Paulina Kostrzewa, published on 2016.

19. "To Study the Partial Replacement of Cement by GGBS & RHA and Natural sand by Quarry Sand in Concrete" by Sonali K. Gadpalliwar, R. S. Deotale, Abhijeet R. Narde, published on March 2014.

20. "Utilization of Various Waste Materials in Concrete" by Nilesh K. Vasoya, Dr. Harishkumar R. Varia, published on 04 April 2015.

21. "Use of Waste materials in the Production of Concrete" by Jorge de Brito, R. V. Silva, published on January 2015.

22. "Experimental study of Partial Replacement of Fine Aggregates with waste Material from China Clay Industry" by A. Seeni, Dr. C.Selvamon, Dr. S. U. Kannan, Dr. M. S. Ravikumar, published on December 2012.

23. "Concrete Technology" by M. S. Shetty published by S. Chand & Co. Ltd, published on 1997.

24. "IS 456 – 2000, Code of Practice for Plain and reinforced Concrete", Bureau of Indian standards, New Delhi.

25. "IS 516 – 1959, Method of Test for Strength of Concrete", Bureau of Indian Standards, New Delhi.

26. "IS 10262 – 2009, IS Method of Mix Design", Bureau of Indian Standards, New Delhi.

27. "IS 383 – 1970, Specification for Coarse and Fine Aggregates for Natural Source for Concrete".

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