7TH

Conference on Sustainability in Civil Engineering

(An International Conference)

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BOOK OF ABSTRACTS

DEPARTMENT OF CIVIL ENGINEERING
CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

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Foreword

Welcome to the CSCE 2025, 7th Conference on Sustainability in Civil Engineering (CSCE'25 – An international Conference) is held by Department of Civil Engineering, Capital University of Science and Technology, Islamabad, Pakistan. The main focus of CSCE'25 is to highlight sustainability related to the field of civil engineering. It aims to provide a platform for civil engineers from academia as well as industry to share their practical experiences and different research findings in their relevant specializations. We hope all the participants experience a remarkable opportunity for the academic and industrial communities to address new challenges, share solutions and discuss future research directions. The conference accommodates several parallel sessions of different specialties, where the researchers and engineers interact and enhance their understanding of sustainability in the civil engineering dynamics.

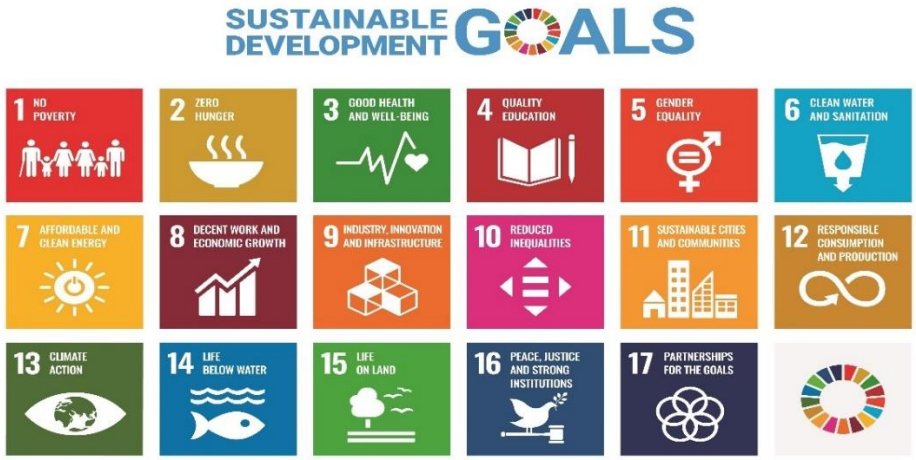
This year, we have nine wonderful and renowned keynote speakers for this edition of CSCE. We have received 109 manuscripts from different countries around the world including USA, Canada, UK, Italy, Germany, Australia, Estonia, China, Japan, South Korea, Malaysia, UAE, KSA, and Pakistan. All papers have under gone a comprehensive and critical double-blind review process. The review committee is comprised of 43 PhDs serving in industry and academia of USA, UK, Ireland, Australia, New Zealand, Norway, France, Poland, Turkey, China, Hong Kong, Malaysia, Singapore, UAE, Oman, Bahrain, Morocco, KSA, and Pakistan. After the screening and review process, 46 papers are to be presented in the conference.

We are grateful to all the reviewers and keynote speakers who have dedicated their precious time to share their expertise and experience. With this opportunity, we would also like to express our gratitude to everyone, especially all the faculty and staff at the Capital University of Science and Technology for their great support and participation. In this regard, the participation and cooperation of all authors, presenters and participants are also acknowledged, without whom this conference would not have been possible. Last but not least, an appreciation to our advising and organizing committees whose hard work and dedication has made this day possible.

Dr. Majid Ali

Convener

CSCE'25



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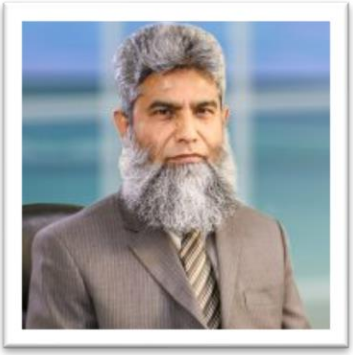

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Dr. Khairunisa Binti Muthusamy *Universiti Malaysia Pahang, Malaysia*	*Eco-Innovation in Construction: Harnessing Industrial Waste for Greener Concrete*
Dr. Inam Khan *Building & Construction Research & Consultancy (BCRC), Australia*	*Shaping Future Sustainability through Durability Modelling and Low Carbon Concrete*
Dr. Libo Yan *Technische Universität Braunschweig & Fraunhofer WKI, Germany*	*Advancing Sustainability through Timber, Natural Fibres, and Recycled Materials in Concrete*
Dr. Wen Si *University College Dublin, Ireland*	*Rheology and Printing Parameters in 3D-Printed Concrete: A Review Toward Improved Printability and Structural Performance*
Dr. Usama Zafar *Saitama University, Japan*	*Rethinking Soil–Pile Interaction: The Critical Role of Nonlinearity Under Dynamic Vertical Loading.*
Dr. Mohsin Usman Qureshi *Sohar University, Oman*	*Sustainable Industrial By-product Utilization in Civil Engineering Applications*
Dr. Paul Beetham *Nottingham Trent University, United Kingdom*	*Lessons from UK Research and Practice in Sustainable Ground Engineering*
Dr. Massimo Latour *University of Salerno, Italy*	*Sustainability as a Catalyst for Resilience: Insights from Recent European Research Projects*
Dr. Harry Lee *Texas A&M University, United States of America*	*Double-diffusive Salt Fingers in the Sea and its Large-scale Influence on Local Climate*

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SUSTAINABLE SELF-COMPACTING CONCRETE INCORPORATING WHEAT STRAW ASH AND FLY ASH AS CEMENT REPLACEMENTS

[a] Farah Naz, [b] Umer Shahzad, [c] Shiraz Baloch*

a: Department of Civil Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, Punjab, Pakistan. farah.naz@kfueit.edu.pk
b: Department of Civil Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, Punjab, Pakistan. umer.shahzad@kfueit.edu.pk
c: Department of Civil Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, Punjab, Pakistan. meershiraz17@gmail.com
* Corresponding author

Abstract- The rapid growth of the construction industry has led to an increasing demand for cement, a material whose production consumes large amounts of energy, depletes natural resources, and emits significant quantities of carbon dioxide into the atmosphere. This emission of greenhouse gases contributes to environmental degradation and climate change. At the same time, agricultural and industrial wastes such as fly ash and wheat straw ash are often discarded improperly, posing serious environmental hazards due to the release of toxic gases. This study investigates the potential of using these organic waste materials as partial replacements for cement in the development of ecofriendly self-compacting concrete. The goal is to reduce cement consumption while promoting sustainable construction practices. In this experimental work, self-compacting concrete was prepared with varying replacement levels of cement at 5%, 10%, 15%, 17% and 20% using fly ash and wheat straw ash. A polycarboxylate based superplasticizer was used to improve the workability of the mix without affecting its strength. The performance of each mix was evaluated through tests on workability and compressive strength. The results demonstrated that selected combinations of organic waste materials not only enhanced the fresh properties of self-compacting concrete but also maintained adequate strength compared to conventional concrete. This research supports the use of agricultural and industrial byproducts as sustainable alternatives in concrete production, offering both environmental and economic benefits while contributing to the advancement of green construction practices.

Keywords- Ecofriendly Concrete, Cement Replacement, Sustainable Construction, Self-Compacting Concrete

ENHANCING CONCRETE SUSTAINABILITY: NATURAL FIBRE REINFORCEMENT FOR SHRINKAGE CRACK MITIGATION IN CONCRETE STRUCTURES

[a] Muhammad Zain Sajid*, [b] Faisal Mateen

a: 496 Engineering Group, Frontier Works Organization (FWO), Rawalpindi, Pakistan. zainsajid2019@gmail.com
b: Structural Works Department, WSP Pvt. Ltd, Sydney, Australia. Faisal.civil@gmail.com
* Corresponding author

Abstract- Shrinkage cracking is one of the most common flaws encountered in reinforced cement concrete (RCC) structures, primarily due to volumetric changes caused by moisture loss and improper curing. These cracks can significantly compromise the durability, aesthetics, and serviceability of concrete elements. This review explores the application of natural fibre reinforcement as a sustainable and effective solution to mitigate shrinkage cracks in concrete structures. Unlike synthetic fibres, natural fibres are biodegradable, cost-effective, and environmentally friendly aligning with global sustainability goals. A detailed review of crack types, fibre characteristics, governing parameters for shrinkage, and fibre volume dosage considerations was conducted using recent literature and the results are thoroughly reported. Key standards such as ACI 544.3R-08, ASTM C1116, and EFNARC guidelines were referenced to establish acceptable fibre content and performance benchmarks. Findings show that natural fibres like jute, sisal, and coconut, at optimized volume fractions, enhance crack resistance, increase flexural strength by up to 89%, reduce water absorption by approximately 25%, and improve concrete's post-crack behavior and mechanical properties. This review aims and supports the use of natural fibres in concrete not only as a technically sound method for crack control but also as a step forward in achieving sustainable and resilient construction practices.

Keywords- Fibre Volume Fraction, Fibre-Reinforced Concrete (FRC), Shrinkage Cracks, Sustainable Construction

EFFECT OF CURING METHOD ON COMPRESSIVE STRENGTH OF MORTAR CONTAINING TIN TAILING AS FINE AGGREGATE REPLACEMENT

[a] Norasyimah Ahmad*, [b] Khairunisa Muthusamy, [c]Nor Rashidah Bahar

a: Faculty of Civil Engineering and Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26300 Kuantan, Malaysia.
syima484@gmail.com
b: Faculty of Civil Engineering and Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26300 Kuantan, Malaysia.
pro@umpsa.edu.my
c: Faculty of Engineering Technology, Universiti Tun Hussien Onn Malaysia Higher Education Hub, 84600 Pagoh, Malaysia.
eftk@uthm.edu.my
* Corresponding author

Abstract- Sand mining leads to various environmental issues due to the extensive use of sand in cement mortar production. Concurrently, tin tailing (TT), a mining industry byproduct, accumulate rapidly and contribute to environmental pollution when disposed of in dumping sites. This study explores the sustainable recycling of TT by partially replacing fine aggregates in mortar and examines the influence of curing methods on the compressive strength of TT-incorporated mortar. Mortar specimens with varying TT replacement levels (0–100%) were cured under two conditions: air curing and water curing, and tested at 7, 28, 60, 90, and 180 days. Results demonstrate that water curing significantly improves compressive strength compared to air curing, attributed to enhanced hydration. An optimal TT replacement of 20% was identified, providing the highest strength under both curing regimes, while higher TT contents led to strength reductions due to altered microstructure and moisture behavior. These findings underscore the importance of curing techniques in optimizing the mechanical performance of TT- based mortars and support the environmentally responsible reuse of mining waste, reducing reliance on natural sand and promoting sustainable construction practices.

Keywords- Compressive Strength, Curing Regimes, Mortar, Tin Tailing

DEVELOPMENT AND PERFORMANCE OF PAPERCRETE AS AN ECO-FRIENDLY CONSTRUCTION MATERIAL

[a] Moiz Ali Haider*, [b] Subhan Shafique, [c] Muhammad Zohaib Asim

a: Civil Engineering Dept., National University of Technology, NUTECH, Islamabad, Pakistan. moizalif23@nutech.edu.pk
b: Civil Engineering Dept., National University of Technology, NUTECH, Islamabad, Pakistan. subhanshafiquef22@nutech.edu.pk
c: Civil Engineering Dept., National University of Technology, NUTECH, Islamabad, Pakistan. muhammad.zohaib@nutech.edu.pk
* Corresponding author

Abstract- In view of the increasing need for environmentally friendly building materials, this research examines the impact and features of papercrete (a mixture of shredded recycled paper added to concrete) as a green and innovative partial substitute for conventional concrete. The study investigates the material's feasibility for sustainable construction, with a primary focus on replacing sand. To evaluate compressive strength, different replacement levels containing 2% and 5% replacement levels of sand and cement were tested under standard curing ages, 5% cement replacement proved the remarkable decrease in compressive strength, pointing towards a deteriorated matrix and weak bonding of particles. In contrast, replacing 2% of the sand had minimal effects on compressive strength, indicating that wastepaper serves as a good lightweight filler material. But sand replacement of 5% started negatively influencing the compressive strength. The results encourage partial use of wastepaper, which can result in a sustainable, lightweight, and economical concrete appropriate for non-structural components such as partition blocks, interior walls, and plastering. The research contributes to the development of green building technology through reframing waste as a precious material.

Keywords- Eco-Friendly Concrete Mix, Papercrete, Sustainable Construction, Waste Paper Reuse

RECYCLED NYLON FIBERS FOR CRACK CONTROL IN HIGH STRENGTH CONCRETE- A USE CASE IN POWERHOUSE

[a] Umar Zakria*, [b] Riaz Ul Haq

a: Mott MacDonald International, Pakistan. umar.zakria@gmail.com
b: Salalam Al Jazeera Construction, Saudi Arabia. engr.riaz77@outlook.com
* Corresponding author

Abstract- Shrinkage cracking in concrete structures, particularly in ultra-high strength concrete used in large-scale infrastructures such as hydropower powerhouse buildings, poses a significant threat to structural integrity and long-term durability. This review explores the effectiveness of nylon fiber-reinforced concrete (NFRC) in mitigating shrinkage-induced cracking. Findings from experimental studies show that incorporating nylon fibers (NF) at concentrations above 2% by volume reduces shrinkage by up to 5% compared to conventional concrete. Additionally, using an optimized water-cement ratio, such as 0.42, in combination with carefully selected NF content, was shown to significantly reduce crack length with an increase of just 0.05% in NF content lowering crack length to 52 mm. The review highlights the critical role of fiber length and type, demonstrating that synthetic fibers (12–54 mm) improve shrinkage resistance, with 54 mm fibers achieving a 62.4% reduction. However, excessive fiber dosage (beyond 1.5%) may lead to void formation and reduced compaction. The incorporation of recycled nylon fibers from waste materials such as fishing nets and textiles not only improves post-cracking toughness and tensile strength but also promotes environmental sustainability. Field applications in hydropower projects have validated NFRC's resilience under thermal and moisture variations, achieving a significant reduction in maintenance costs over a decade. In conclusion, NFRC presents a promising solution for enhancing durability and sustainability in high-performance concrete structures, particularly in critical infrastructure applications.

Keywords- Shrinkage Cracks, Nylon Fibers, NFRC, Hydropower

FIBER REINFORCEMENT FOR DRYING SHRINKAGE MITIGATION IN CONCRETE: A COMPREHENSIVE REVIEW

[a] Abu Bakar Naeem*, [b] Syed Ilyas Ali Shah

a: Project Supervision Department, Maven Projects LLP, Islamabad, Pakistan. r_abubakar@hotmail.com
b: Quality Control Department, Steel mains, Australia. ilyasshah546@gmail.com
*Corresponding author

Abstract- A comprehensive review presents a detailed review of the key challenges and advanced solutions addressing drying shrinkage in concrete structures. Drying shrinkage is a major issue in concrete, often resulting in cracking and decreased durability. There are many factors which affect the creation of drying shrinkage cracks like water to binder ratio, cement type and environmental conditions. The integration of fiber into concrete offers promising solutions yet its effectiveness is based on its type, quantity and density. This study systematically evaluates drying shrinkage governing properties and use of different fibers to mitigate it. The use of rice straw, basalt fiber, vegetable fiber, cotton fabric and textile waste, non-cellulose and steel fibers are discussed. The blending approach is the key to achieving best results like basalt fiber and nanosilica. A comprehensive literature review exploring different research computing experimentally shrinkage effects, it governs parameters and controlling through fiber reinforcement. Fibers are assessed based on their density, tensile strength, shrinkage reduction and improving ductility. Data was reviewed to look at the performances of different fibers used alone or in combination for performance and serviceability. Steel and Nanocellulose fibers are found most effective in mitigating drying shrinkage while natural fibers offer moderate benefits. Basalt and nanosilica fiber provided excellent ductility and tensile strength. Cotton knitted fiber and textile waste fiber significantly increase flexural strength and toughness. Introduction of fibers improves concrete mechanical properties and provide enhanced performance and longevity.

Keywords- Drying Shrinkage Cracks, Durability, Cotton Knitted Fibre, Steel Fibre, Sustainability, Textile Waste

AN OVERVIEW ON THE PERFORMANCE OF STEEL FIBER REINFORCED COMPOSITES IN RESTRAINING CONCRETE PLASTIC SHRINKAGE CRACK IN SLAB

[a] Abu Bakar*, [b] Hamza Khan

a: Site Engineer, NESPAK, Islamabad, Pakistan. chabubakar2003@gmail.com
b: Quality Control Lead, Aljafer General Contracting, KSA. hamzathekhan619@gmail.com
* Corresponding author

Abstract- Early-stage plastic shrinkage cracks can shorten the lifespan of concrete slabs by providing direct pathways for aggressive agents to enter and hastening environmental attack-related deterioration, especially in hot and windy conditions. For concrete constructions to be long-lasting and sustainable, these fissures must be fixed. To enhance the sustainability and resilience of concrete structures, this study evaluates the performance of steel fiber reinforced composites (SFRC) in mitigating early age plastic shrinkage and micro-cracking under various environmental conditions. In accordance with ASTM C1579, the plastic shrinkage tests were conducted in a specially constructed chamber. The effects of various environmental factors on compressive strength and fracture potential are investigated. The SFRC is preferable because it is more evenly distributed throughout the concrete volume, and it has been demonstrated to be effective in reducing microcracks and plastic shrinkage through the application of the crack reduction ratio (CRR). Results from previous researches also indicates that a dosage of 30 kg/m³ of SFRC is effective in preventing or significantly reducing cracking, even under extreme conditions. These findings contribute to the development of more durable concrete slabs capable of withstanding climate-induced stressors.

Keywords- Steel Fiber Reinforced Composites, Plastic Shrinkage Cracks, Concrete Shrinkage, Concrete Durability

EFFECTIVENESS OF NYLON FIBERS IN CONTROLLING SHRINKAGE CRACKING IN CONCRETE PAVEMENTS

[a] Abdul Wadood*, [b] Raja Arsalan

a: Fellow Builders, Works Department, Islamabad, Pakistan. abdulwadoodraaj@gmail.com
b: Structural Engineer, Estonia. raja47x@gmail.com
* Corresponding author

Abstract- The road infrastructure is a vital component of national economic development; however, it is increasingly challenged by sustainability concerns stemming from material deterioration, insufficient maintenance, and harsh environmental exposure. Although rigid pavements are valued for their extended service life, they are susceptible to premature cracking, primarily due to drying shrinkage. This phenomenon occurs when volumetric reduction in concrete induces tensile stresses that exceed its capacity, leading to early-age cracking. These cracks are further exacerbated by repeated traffic loads, compromising both performance and longevity. This study aims to identify the underlying factors contributing to shrinkage-induced cracking in rigid pavements and to evaluate strategies for enhancing their post-cracking resistance. In particular, the effectiveness of nylon fibers as a reinforcement material is explored. An experimental framework is employed to investigate the fibers' role in controlling crack propagation through bridging mechanisms and improved tensile behaviour. The results demonstrate that nylon fiber integration significantly enhances resistance to shrinkage stresses, leading to improved durability and an extended lifespan for rigid pavement systems.

Keywords- NFRC, Rigid Pavement, Shrinkage Cracking, Tensile Strength

ENHANCING FLEXURAL STRENGTH IN CONCRETE ONE-WAY SLABS OF BUILDING THROUGH COTTON FIBER REINFORCEMENT

[a] Abu Bakar Naeem*, [b] Syed Ilyas Ali Shah

a: Project Supervision Department, Maven Projects LLP, Islamabad, Pakistan. r_abubakar@hotmail.com
b: Quality Control Department, Steel mains, Australia. ilyasshah546@gmail.com
*Corresponding author

Abstract- Concrete inherent brittleness and low tensile strength and require reinforcement in flexural members like one-way slabs, to mitigate cracking and structural failures under flexural loading. Steel is mostly used as reinforcement to enhance flexural strength of concrete. The manufacturing of steel reinforcement produces significant carbon emissions which causes environmental pollution. The purpose of this study is to make sustainable concrete with fiber reinforcement and reduce steel usage. By using pure Cotton fiber, it seeks to develop an ecofriendly composite that balances structural stability with environmental sustainability. After obtaining Cotton fiber from reliable resource, 2-inch-long fiber was made. Different trials were done to avoid balling effect in concrete, best was to place material in layers for proper mixing. 5 layered concrete mix was found better with water to binder ratio 0.55. Beamlets are made for testing purpose. Cotton fiber reinforced concrete presented 17% to 73% more flexural strength as compared to the plain cement concrete. With results from flexural strength of beamlet, one-way slab can be designed analytically. There is substantial potential for further research into cotton fibers with longer fiber lengths, as well as the use of textile waste to achieve more sustainable outcomes.

Keywords- Cotton Fiber, Flexural Strength, Modulus of Rupture, Plain Cement Concrete, Textile Waste Fiber

ENHANCING CRACK FLEXURAL RESISTANCE IN HYDRAULIC STRUCTURES THROUGH NYLON FIBER REINFORCED CONCRETE

[a] Umar Zakria*, [b] Khurram Munir

a**:** Mott MacDonald International, Pakistan. umar.zakria@gmail.com
b: School of Engineering, RMIT University, Melbourne, Australia. khurramshahzad.munir@rmit.edu.au
*Corresponding Author

Abstract- Flexural cracking in concrete structures, particularly in hydraulic infrastructures such as tailrace culverts, compromises durability and escalates maintenance costs. This experimental study investigates the efficacy of nylon fiber-reinforced concrete (NFRC) in mitigating flexural cracks, with a focus on recycled nylon fibers (1.01 mm diameter), sourced from fishing nets to enhance sustainability. Experimental methodology included flexural testing (ASTM C78/C293) of beamlets (100×100×450 mm) with 54 mm nylon fibers at 2% volume fraction, alongside slump tests (ranging from 65–101 mm) and fracture surface analysis. Results demonstrated that NFRC achieved a 34% lower modulus of rupture (MOR) than plain concrete (PC), with post-cracking ductility enabling up to 3 times greater deformation capacity (at 4.60 kN peak load vs. PC's 7.78 kN). The fiber's bridging mechanism reduced crack propagation by 40% in tailrace lining walls and lowered water absorption by 30%, critical for hydraulic structures. A 1:4:2 mix ratio, 0.5 water-to-cement ratio, and 54 mm fiber length resulted in a reduction of flexural cracks. When the fiber dosage exceeded 1.5%, voids formed and workability decreased, as indicated by collapsed slump values. Fractures surface analysis revealed dual failure modes: 60% fiber pull-out and 40% rupture, explaining NFRC's energy absorption, 2.8 times higher than PC. This experimental study highlights NFRC's dual benefits mechanical resilience and environmental viability. These findings support NFRC's use in hydropower infrastructures, particularly for hydraulic structures, requiring crack resistance and durability under cyclic hydraulic loads.

Keywords- Flexural Cracks, NFRC, Nylon Fibers, Tailrace Culverts

EXPERIMENTAL INVESTIGATION ON THE FLEXURAL BEHAVIOR OF STEEL FIBER IN CONCRETE

[a] Usman Khalid*, [b] Naveed Irshad

a: Public Works Department (PWD), Mirpur, Pakistan. usmankhalid78646@gmail.com
b: Head of Group Strategic Sourcing, Edotco Group, Malaysia. naveed.irshad@edotcogroup.com
*Corresponding author

Abstract- Concrete is valuable for construction because of its strong resistance to compression, but it can break easily under bending stresses. To improve both the durability and service life of concrete, its flexural strength must be enhanced. This study intends to evaluate whether infusing 5% steel fibers by cement weight can lead to better flexural strength and crack resistance in concrete than plain cement concrete (PCC). Workability is assessed by testing slump on samples of concrete made with and without steel fibers. The performance of the mixes is evaluated in flexural tests and the samples are also checked visually to observe the pattern of cracking. Slump values and crack patterns are recorded to observe the impact of steel fibers on concrete's behavior. The slump of SFRC is smaller than that of PCC, demonstrating that the fiber content decreases the workability of concrete. SFRC has showed a higher bending strength i.e. 28% more than PCC. Examining the surface shows that SFRC forms less and narrower cracks, showing that steel fibers randomly arranged make the material tougher. The findings indicate that 5% steel fibers ensure stronger flexural behavior in concrete.

Keywords- Steel Fiber Reinforced Concrete, Flexural Strength, Crack Resistance, Workability

COMPARATIVE STUDY OF NYLON FIBER REINFORCED CONCRETE WITH PCC FOR COMPRESSIVE STRENGTH AND WORKABILITY

[a] Muhammad Mursaleen*, [b] Ameer Turab

a: Department of Construction Management, Halcrow Pakistan (Pvt) Limited, Islamabad, Pakistan.
mursaleenmuhammadjhg@gmail.com
b: Department of Civil Engineering, Hochschule Stendal Magdeburg, Germany. ameer.turab@stud.h2.de
* Corresponding author

Abstract- The influence of nylon fiber addition on the workability and compressive strength of concrete is studied in this investigation. Two concrete mixes, Plain Cement Concrete (PCC) and Nylon Fiber Reinforced Concrete (NFRC), were prepared using Ordinary Portland Cement (OPC), fine sand, crushed granite aggregates, potable water, and synthetic nylon fibers 50 mm long. NFRC mix included nylon fibers at 3% of cement weight by weight with a mix proportion of 1:4:2 A higher proportion of fine aggregates mix helps create a denser matrix and improves fiber bonding and a water-cement proportion of 0.6, whereas PCC used a traditional 1:2:4 proportion with a 0.5 water-cement proportion. The tests were conducted on fresh concrete according to standard slump and temperature tests, as well as compressive strength tests after 28 days of water curing in accordance with ASTM standards. Results showed that NFRC recorded a greater slump in value (190 mm) than that of PCC (150 mm), proving better workability. NFRC indicated slightly lower mean compressive strength (7.07 MPa) than PCC (9.05 MPa) due to possible increased water content and fiber hindrance in compaction. Even with a decrease in strength, NFRC had less variability and was more consistent. These results indicate that NFRC is ideal for non-structural uses with improved workability and resistance to cracking like pavements, overlays, and precast components where ductility and toughness take precedence over maximum compressive strength.

Keywords- Nylon Fiber, Compressive Strength, Durability, Mix Design, Sustainability

ENHANCING TENSILE PERFORMANCE OF CONCRETE USING STEEL FIBER REINFORCEMENT: AN EXPERIMENTAL STUDY

[a] Awais Sikandar*, [b] Faheem Ahmad Gul

a: Civil Engineering Department, APCOMS, Rawalpindi, Pakistan. awaissikandar786abc@gmail.com
b: School of Civil and Architectural Engineering, Nanchang Institute of Technology, Nanchang 330099, China. faheem@nit.edu.cn
* Corresponding author

Abstract- Conventional concrete, despite its widespread use, exhibits low tensile and shear strength, often leading to brittle failure under stress if not adequately reinforced. To address this limitation, steel fibers are increasingly employed to enhance mechanical performance. The effectiveness of Steel Fiber Reinforced Concrete (SFRC) largely depends on the bond between the fibers and the surrounding concrete matrix. This bond influences critical factors such as fracture initiation, crack spacing, and crack width. A comprehensive understanding of these bond mechanisms is essential for optimizing SFRC performance. This study investigates the role of steel fiber reinforcement in improving tensile behavior, highlighting that incorporating up to 5% steel fibers significantly increases the tensile strength of concrete. Furthermore, the inclusion of fibers enhances the pull-out resistance, contributing to improved crack control and overall structural integrity. The findings support the practical application of SFRC in structures requiring enhanced toughness and durability.

Keywords- Bond Behavior, Crack Control, Steel Fiber Reinforced Concrete (SFRC), Tensile Strength Enhancement

EXPERIMENTAL EVALUATION OF FLEXURAL BEHAVIOR IN CONCRETE BEAMS REINFORCED WITH WASTE HUMAN HAIR FIBERS

[a]Jawad Nasar*, [b]Adeer Khan

a: Askari Heights V, Housing Directorate, Islamabad, Pakistan, jawad100eb@gmail.com
b: Korea Advanced Institute of Science & Technology, Daejeon, South Korea, adeerkhan@kaist.ac.kr
*Corresponding author

Abstract- Concrete is the most widely used construction material globally, but it faces inherent challenges such as low tensile and flexural strength and a tendency to crack under stress. Traditional fibers like steel and polypropylene are used to mitigate these issues; however, they are often costly and nonbiodegradable, prompting the search for sustainable alternatives. This study explores the innovative use of human hair, a natural, biodegradable, and high tensile waste material as a reinforcing additive in concrete beams. The novelty lies in evaluating the structural and durability performance of concrete beams reinforced with human hair, an underexplored fiber in flexural applications. An experimental program was carried out where four concrete beams were cast, two with 1% human hair by cement volume and two without hair as control specimens. Tests conducted included a three-point flexural test, water absorption test, and surface hardness test using the Schmidt hammer. Specimens were cured for 28 days before testing. Results showed that human hair reinforced beams exhibited 23.84% higher flexural strength compared to controls, reduced water absorption, and increased surface hardness. These findings suggest that human hair can be effectively utilized as a sustainable and efficient fiber additive to enhance concrete performance.

Keywords- Human Hair, Concrete, Flexural Strength, Schmidt Hammer, Water Absorption

COTTON FIBERS FOR IMPROVED CONCRETE TENSILE STRENGTH AND CRACK RESISTANCE IN SLABS

[a] Mobeen Anwar*, [b] Sadia Sajid Khan

a: Structural Designing, Niazi Design Systems, Islamabad, Pakistan. mobeenanwer94@gmail.com
b: Design and Estimation Department, Kinetic International FZE, UAE. sadialohani@hotmail.com
*Corresponding Author

Abstract- Concrete is one of the most used materials in construction because of its high compressive strength. However, it tends to perform poorly under tensile stress, often resulting in cracks and reduced service life of structures. In this study, experimental investigation is done to explore whether adding cotton fiber repurposed from post-industrial textile waste can help improve the tensile behavior of concrete. This approach not only targets mechanical enhancement but also introduces an environmentally conscious alternative to conventional synthetic fibers. To evaluate this, cylindrical specimens of both plain cement concrete (PCC) and cotton fiber-reinforced concrete (CFRC) were prepared, with 0.5% cotton fiber added by weight in the CFRC mix. After 28 days of water curing, the samples were tested using a Universal Testing Machine (UTM) as per ASTM C496 standards. The performance was assessed based on tensile strength. Interestingly, while CFRC samples showed a slightly lower tensile strength (0.8 MPa) compared to PCC (0.9 MPa), they demonstrated much better ductility and crack control. The cotton fibers acted as internal bridges, slowing down crack formation and allowing the material to absorb more energy before failure increasing toughness up to 7 times. These results suggest that CFRC, despite a modest reduction in peak tensile strength, could be a strong candidate for use in applications where long-term durability and crack resistance are key priorities.

Keywords- Tensile Strength, Cotton Fibers, Crack Resistance, Sustainable Concrete

FIBER-REINFORCED CONCRETE FOR CRACK RESISTANCE: A REVIEW STUDY

[a] Usman Khalid*, [b] Emmad Cheema

a: Public Works Department (PWD), Mirpur, Pakistan. usmankhalid78646@gmail.com
b: Civil Engineering Analyst, AtkinsRéalis, Canada. emmad.cheema@gmail.com
* Corresponding Author

Abstract- Concrete is widely recognized for its high compressive strength when compared with other construction materials. Nevertheless, it has critical flaws, as low tensile strength, brittleness and vulnerability to crack propagation. Plastic shrinkage and thermal cracking are two of the most critical early age cracking problems in concrete structures in hot climates. Plastic shrinkage cracking occurs when surface moisture loss from high temperature, low humidity and wind occurs rapidly before the concrete sets. Whereas, thermal cracking results from internal temperature gradients that are established during cement hydration and the thermal expansion behavior of aggregates. Focusing on the effectiveness of both plastic shrinkage and thermal cracking, two commonly occurring types of cracking, this study investigates the potential of various fiber types including steel, polypropylene, glass, basalt, carbon, and natural plant fibers. Among these, steel fibers are noticeably superior than the others, in resisting both forms of cracking because of their high tensile strength, crack bridging, and thermal stability. The research concludes that use of steel fibers in concrete mix designs can greatly enhance the structural integrity and service life of concrete subjected to extreme environmental exposure.

Keywords- Compressive Strength, Brittleness, Plastic Shrinkage, Thermal Cracking, Steel Fiber

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Capital University of Science and Technology, Islamabad Pakistan

AN OVERVIEW OF THE EFFECTS OF STEEL FIBER REINFORCED COMPOSITES ON FLEXURAL CRACKING IN CONCRETE

[a] Awais Sikandar*, [b] Faheem Ahmad Gul

a: Civil Engineering Department, APCOMS, Rawalpindi, Pakistan. awaissikandar786abc@gmail.com
b: School of Civil and Architectural Engineering, Nanchang Institute of Technology, Nanchang 330099, China. faheem@nit.edu.cn
* Corresponding author

Abstract- Cement concrete is the most widely used construction material globally, attributed to its excellent workability and moldability. However, its inherently low tensile strength, minimal ductility, and high susceptibility to cracking limit its application without reinforcement. These deficiencies often result in the formation of internal microcracks that compromise the material's structural integrity. As modern civil engineering structures demand higher performance and durability, conventional concrete must be enhanced to meet these evolving requirements. The incorporation of various fiber types into concrete mixtures has shown promising improvements in mechanical performance, durability, and serviceability. Among these, Steel Fiber Reinforced Concrete (SFRC) has demonstrated exceptional crack resistance and control. SFRC significantly improves tensile strength of concrete under flexural loading, by bridging cracks and preserving the integrity of the matrix even after extensive cracking. This paper provides an overview of the effectiveness of steel fiber composites in enhancing the structural behavior of concrete, with a focus on mitigating flexural cracking.

Keywords- Concrete Durability, Flexural Cracking, Steel Fiber Reinforced Concrete, Tensile Strength Enhancement

A REVIEW OF MECHANICAL PERFORMANCE AND SUSTAINABILITY OF NYLON FIBER IN CONCRETE BEAM REINFORCEMENT

[a] Qazi Muhammad Tariq*, [b] Blawal Hasan

a: Civil Engineering, Cost Umbrella, Islamabad, Pakistan. qazitariq581@gmail.com
b: Sr. Architect, Contracting and Construction Enterprises, Saudi Arabia. engr.blawal.hasan@gmail.com
*Corresponding author

Abstract- In today's world, one of the persistent problems in civil engineering is the formation of concrete cracks due to shrinkage, temperature changes, and load stressors. Traditional polishing methods place little to no emphasis on preventing or resisting micro-cracks. The specific aim of this study is to evaluate the behavior of concrete against cracking with the addition of Nylon Fiber as reinforcement. The study analyzes research conducted over the last ten years on the effects of adding Nylon Fiber to concrete in varying percentages. Recent experiments have shown that the addition of Nylon Fiber significantly improves the tensile, flexural, and compressive strength of concrete. In particular, for projects that require shortened construction periods, the incorporation of such fiber is highly beneficial. Nylon Fiber enhances the sustainability of concrete by reducing the need for traditional steel reinforcement, thereby also lowering long-term maintenance costs. Nylon Fiber-reinforced concrete presents a promising solution for improving the performance of reinforced concrete beams, especially in seismic applications.

Keywords- Cracking, Durability, Fiber Reinforced Concrete (FRC), Shrinkage, Strength

ENHANCING THE FLEXURAL STRENGTH OF CONCRETE BEAMS USING NYLON FIBERS AS SUSTAINABLE REINFORCEMENT

[a] Qazi Muhammad Tariq*, [b] Blawal Hasan

a: Civil Engineering, Cost Umbrella, Islamabad, Pakistan. qazitariq581@gmail.com
b: Sr. Architect, Contracting and Construction Enterprises, Saudi Arabia. engr.blawal.hasan@gmail.com
*Corresponding author

Abstract- In today's world, one of the problems that persists over time in civil engineering is the formation of concrete cracks because of shrinkage, temperature changes, and load stressors. With traditional polishing methods, few to no efforts are placed in stopping the resistance of micro-cracks. This particular study is meant to assess the degree of effectiveness that adding nylon fiber to concrete as a reinforcing material has in increasing durability, cracking, and tensile strength. The study analyzes the works of others over the last ten years when nylon fiber was added to concrete in varying percentages. This research investigates the flexural behavior of Plain Cement Concrete (PCC) reinforced with locally available nylon fibers (known as BAAN). A mix design incorporating 3% nylon fibers by volume was tested for fresh and hardened properties. Also, several construction projects in the recent past measure compressive strength, tensile strength, and crack resistance. Results showed that the incorporation of nylon fibers improved the flexural strength significantly compared to expected values for plain concrete. Nylon fiber reinforced concrete presents a very promising solution in terms of improving the performance of reinforced concrete beams, particularly under seismic applications. Nylon fibers make concrete more sustainable by reducing the amount of traditional steel reinforcement that can be used in concrete and, therefore also reducing long-term maintenance costs.

Keywords- Concrete, Durability, Flexural Cracks, NFRC, Nylon Fibers

PERFORMANCE EVALUATION AND APPLICATION POTENTIAL OF NYLON FIBERS IN CONCRETE SLAB -A REVIEW

[a] Usama Akhter*, [b] Hamdan Ullah

a: Civil Engineering Department, Hazara University, Mansehra, Pakistan. usamaakhtarswati@gmail.com
b: Safety Engineer (Civil), Bin Omaira Contracting (KSA). eng.hamdan007@gmail.com
*Corresponding author

Abstract- Incorporating fibers into reinforced cement concrete increases its impact resistance and earthquake load bearing capacity by improving the stiffness or energy absorption capability of the concrete material. A significant feature of fibers, like "bridge effect" during early crack propagation of concrete, comes into effect. Because of this, fibers restrain the crack formation and propagation, which improves the strength and ductility of concrete civil structure. The focus of this study is between the mechanical properties of reinforced cement concrete with nylon fiber and without it. In this case, data from previous article will be used to compare the strengths of nylon fiber reinforced concrete to conventional concrete using compressive strength test, flexural strength test, and split tensile strength test. Mixing fiber with cement increases the reduction of water content which diminishes the workability of the concrete, creating fiber balls. Due to the heterogeneity associated with fibrous materials, the efficacy of fiber reinforced concrete is reduced. The static mixer works best for strand-based fibers, which helps inline glass fibers to enhance concrete strength. During the integration of small amounts of fibers into dry concrete, the problem of fiber distribution can be solved by proper placement and dispersion of the mixtures, which increases concrete strength and prevents fiber conglomeration. Factors like the aspect ratio, fiber volume, and fiber orientation are important for the transmission of stress between concrete mix and the fiber. Impact resistance and flexural toughness of reinforced concrete is greatly improved by nylon fiber, and as a result, the impact-bearing capacity of concrete is enhanced. The addition of nylon fibers enhances the tensile strength of concrete, especially during the post-peak phase, by bridging cracks and improving energy absorption.

Keywords- Nylon Fiber, Concrete Reinforcement, Cracking Resistance, Ductility, Fiber-Reinforced Concrete

DURABILITY OF GEOPOLYMER CONCRETE WITH RECYCLED SAND IN ACIDIC AND MARINE CONDITIONS

[a] Shahzadi Irum*, [b] Faisal Shabbir, [c] Hammad Salahuddin

a: Civil Engineering Department, COMSATS University Islamabad, Wah Campus, Pakistan. Irum.jawad@ciitwah.edu.pk
b: Department of Civil Engineering University of Engineering & Technology Taxila, Pakistan. faisal.shabbir@uettaxila.edu.pk
b: Department of Civil and Transportation Engineering, Shenzhen University, China. Hammads88@szu.edu.cn
* Corresponding author

Abstract- Incorporating recycled sand (R-sand) in geopolymer concrete (GC) not only enhances environmental sustainability by utilizing industrial by-products and construction & demolition waste but also reduces dependency on river sand, making it a more environmentally friendly option. This paper presents an experimental investigation on the behavior of GC with R-sand in acid and marine water. All samples were prepared with a combination of fly ash and slag as a binder, using sodium hydroxide and sodium silicate as alkaline activators. The specimens were exposed to 4% sulfuric acid and artificial marine water for a period of 60days. The parameters that were examined during the experimental investigation are compressive strength, compressive strength loss, mass loss, and water absorption. The results show that the strength of GC gradually reduced with an increased R-sand content, and it performs better in marine water as compared to acidic solution.

Keywords- Acid and Marine Water, Durability of Concrete, Geopolymer Concrete, Recycled Sand

EXPERIMENTAL STUDY ON STRENGTH AND WORKABILITY OF SUSTAINABLE CONCRETE INCORPORATING COTTON FIBERS AND MARBLE WASTE

[a] Muhammad Adnan Hanif*, [b] Ali Ejaz

a: Department of Structural Engineering, Military College of Engineering (NUST), Risalpur, Pakistan. adnanhanif2303@gmail.com
b: Department of Structural Engineering, National Institute of Transportation (NUST), Risalpur, Pakistan. enggaliejax@gmail.com
* Corresponding author

Abstract- This study investigates the dual use of cotton fibers (CF) and waste marble aggregate (WMA) as sustainable alternatives to conventional coarse aggregates in concrete. Driven by environmental concerns and resource depletion, the research introduces five mix designs with WMA ranging from 0% to 100% and a constant 2.5% CF by weight. Compressive and flexural strengths were evaluated at 28 and 56 days. Results revealed a peak performance at 50% WMA, surpassing control values and demonstrating improved mechanical behavior and sustainability. The study supports sustainable engineering practices by reusing industrial waste materials in concrete applications. The findings promote scalable use of industrial waste for non-structural concrete applications aligned with climate-resilient infrastructure goals.

Keywords- Sustainable Concrete, Cotton Fibers, Waste Marble Aggregate, Mechanical Properties

COMPRESSIVE STRENGTH OF STANDARD CYLINDERS, SPLIT TENSILE STRENGTH OF PRESTRESSED CORES, AND MICROSTRUCTURAL ANALYSIS OF POLYPROPYLENE FIBER REINFORCED CONCRETE

[a] Mohammad Zulqarnain*, [b] Muhammad Usman Rashid, [c] Muhammad Awais

a: Civil Engineering Department, University of Engineering and Technology, Taxila, Pakistan. zuuki786@gmail.com
b: Civil Engineering Department, University of Engineering and Technology, Taxila, Pakistan. m.usman@uettaxila.edu.pk.
c: Civil Engineering Department, International Islamic University Islamabad, Islamabad, Pakistan. 25muhammadawais@gmail.com
*Corresponding author

Abstract- This experimental study conducted on mono fiber reinforced concrete to check the effect of polypropylene fibers on compressive strength of standard cylinders and split tensile strength of prestressed cores that are taken out from the prestressed beams. The study also included a microstructure analysis of control and fiber reinforced concrete. The results showed that the PPFRC IV mix achieved an optimum content. Among the mixes, PPFRC IV demonstrated the highest performance, showing a 17% increase in ultimate stress and a 5% increase in split tensile strength compared to the controlled specimen. After 28 days of exposure to sodium chloride solutions, the controlled specimen (CS) and PPFRC I showed the highest percentage loss in strength, reaching up to 11%. Additionally, more open pores were observed in controlled specimen by the SEM analysis. Moreover, hydration products were also observed in SEM analysis. PPFRC IV fibers bonded with the matrix firmly due to which this mix showed improvements in the strength of concrete.

Keywords- Fiber-Reinforced Concrete, Polypropylene Fibers, Split Tensile, Ultimate stress, Microstructure

EXPERIMENTAL STUDY ON THE PERFORMANCE OF DATE PALM SURFACE FIBER REINFORCED CONCRETE UNDER ACIDIC CONDITION

[a] Asad Kareem, [b] Syed Saqib Mehboob*

a: Civil Engineering Department, University of Engineering and Technology, Taxila, Pakistan. asadkarim599@gmail.com
b: Civil Engineering Department, University of Engineering and Technology, Taxila, Pakistan. syed.saqib@uettaxila.edu.pk
* Corresponding author

Abstract- This study evaluates the performance of concrete reinforced with date palm fiber (DPF) as a sustainable and cost-effective alternative to conventional concrete. The experimental program investigates the effects of varying water-to-cement (W/C) ratios (0.60, 0.64, 0.68, and 0.72), DPF content levels (3%, 5%, 7%, and 9% by weight of cement), and cement types on the mechanical strength and acid resistance of concrete. A total of sixteen mix designs were developed and tested for compressive and split tensile strength under standard curing, as well as after 28 days of exposure to a 5% sulfuric acid solution. The results show that lower W/C ratios (0.60–0.64) lead to improved strength characteristics, possibly due to a denser microstructure and reduced void content. Incorporation of DPF at 3%–7% resulted in moderate strength enhancement, which may be attributed to improved internal reinforcement provided by the fibers. However, at 9% DPF content, fiber agglomeration and reduced workability likely contributed to a decline in strength. Acid exposure caused a noticeable reduction in strength across all mixes, with mixtures containing higher W/C ratios and higher fiber contents being more vulnerable. Mixes with W/C ratios of 0.60–0.64 and DPF contents of 5%–7% demonstrated comparatively better retention of mechanical properties under acidic conditions. These findings highlight the potential of optimized DPF-reinforced concrete as a sustainable material for use in aggressive environments such as sewage systems and industrial floors, provided that fiber dosage and mix proportions are carefully selected.

Keywords- Date Palm Fiber, Acid Resistance, Water-Cement Ratio, Durability, Sulfate Attack

A REVIEW ON OPTIMIZING SUSTAINABLE CRACK CONTROL IN SLABS USING COTTON FIBER COMPOSITES

[a] Mobeen Anwar*, [b] Sadia Sajid Khan
a: Structural Designing, Niazi Design Systems, Islamabad, Pakistan. mobeenanwer94@gmail.com
b: Design and Estimation Department, Kinetic International FZE, UAE. sadialohani@hotmail.com
* Corresponding Author

Abstract- Cracking in the base slabs of slabs poses a serious threat to both structural stability and long-term waterproofing performance i.e. Swimming Pools. These cracks commonly arise from early-age shrinkage, thermal expansion and contraction, subgrade settlement, and flexural stress during service life. Traditional concrete lacks the tensile strength and ductility needed to resist these failure modes effectively. Cotton fiber-reinforced concrete (CFRC) has emerged as an eco-friendly, sustainable solution to these challenges by enhancing crack resistance, improving tensile behavior, and promoting internal curing. The fibers not only bridge microcracks but also delay their propagation, thereby extending the service life of concrete structures. This paper provides a detailed assessment of CFRC performance under various stress conditions and failure modes, such as shrinkage-induced cracking and load-induced fracture. A comparative evaluation with conventional synthetic and metallic fibers, namely steel and polypropylene, is also conducted to highlight CFRC's structural and environmental advantages. Furthermore, the study presents real-world applications of CFRC in concrete works and emphasizes the significance of utilizing cotton waste derived from the spun lace process. This process, which eliminates chemical waste associated with traditional cotton treatments, offers a circular economic approach by integrating textile by-products into construction materials. Overall, CFRC presents a promising avenue for enhancing durability and sustainability in modern infrastructure, particularly in water-retaining structures like swimming pools.

Keywords- Crack Control, Fiber-Reinforced Concrete (FRC), Ductility, Shrinkage, Cotton Fiber

MITIGATING FLEXURAL CRACKS IN CONCRETE BEAMS USING DIVERSE FIBERS: A REVIEW

[a]Jawad Nasar*, [b]M. Haider Mehmood Khattak

a: Askari Heights V, Housing Directorate, Islamabad, Pakistan, jawad100eb@gmail.com
b: University of Calgary, Calgary, Canada, muhammadhaidermehmoo@ucalgary.ca
*Corresponding Author

Abstract- Flexural cracking remains a critical challenge in reinforced concrete beams, adversely affecting structural durability and service life. This review investigates the potential of incorporating cotton, glass, and human hair fibers to enhance the flexural performance of concrete. Emphasizing both mechanical behavior and environmental sustainability, the study draws upon 32 peer-reviewed sources published between 2010 and 2025. The selected fibers are evaluated based on tensile properties, crack mitigation capabilities, and applicability in sustainable construction. Comparative analysis reveals that while glass fibers offer superior strength, cotton and human hair fibers present notable benefits in terms of biodegradability and cost-effectiveness. A synthesis of secondary data provides theoretical insight into the fibers' efficacy in resisting flexural stress. The findings support fiber reinforcement as a viable strategy for improving concrete performance while aligning with global sustainability goals.

Keywords- Cotton Fiber, Flexural Cracks, Fiber Reinforced Concrete, Glass Fiber, Human Hair Fiber

DYNAMIC RESPONSE MODELING OF SDOF SYSTEMS USING NEURAL NETWORKS: A COMPARATIVE STUDY OF ANN AND LSTM

[a] Aaqib Najeeb*, [b] Muhammad Yousaf Jalal

a: Department of Structural Engineering, College of Civil Engineering, Tongji University, Shanghai, 200092, China, aaqib_najeeb@tongji.edu.cn
b: State Key Laboratory of Disaster Reduction in Civil Engineering, Tongji University, Shanghai, 200092, China, 2493237@tongji.edu.cn
* Corresponding author

Abstract- Overhead water tanks (OHWTs) play a critical role in infrastructure, yet they are highly vulnerable to dynamic loading such as seismic forces and wind excitations. Traditional numerical methods, such as Finite Element Analysis (FEA), can be computationally intensive, making real-time structural response solving challenging. This study develops a machine learning (ML)-based approach to predict the structural response of OHWTs subjected to harmonic loading by idealizing the structure as a Single Degree of Freedom (SDOF) system, where multiple configurations of mass, stiffness, and damping were considered to represent different structural scenarios. The governing equation of motion (EOM) was numerically solved using MATLAB's ode45 solver, chosen for its balance between accuracy and computational efficiency after comparison with alternative solvers. The computed responses from this step served as the training dataset for the ML models. Artificial Neural Networks (ANN) and Long Short-Term Memory (LSTM) networks are then trained using this dataset to predict structural displacements. The results demonstrate that the LSTM model outperforms the ANN by effectively capturing sequential dependencies in dynamic responses, showing smoother and more accurate predictions. The proposed methodology highlights the potential of integrating ML with numerical simulations for different fields of Structural Engineering. By leveraging AI-driven approaches, this research offers a computationally efficient alternative to conventional methods, paving the way for advanced predictive modeling in civil engineering applications.

Keywords- Structural Response, SDOF System, LSTM and ANN, Numerical Simulations

ANALYSIS AND SIMULATION OF STEEL MEMBERS IN ANSYS AT DIFFERENT TEMPERATURES

[a]Raja Wajahat Zahoor Khan*, [b]Raja Shujahat Zahoor Khan, [c]Muhammad Yaqub

a: Department of Civil Engineering, University of Engineering and Technology, Taxila, Pakistan. wajahatzahoor12@gmail.com

b: Department of Civil Engineering, University of Engineering and Technology, Taxila, Pakistan. shujahatkhan277@gmail.com

c: Department of Civil Engineering, University of Engineering and Technology, Taxila, Pakistan. yaqub_structure@yahoo.com

* Corresponding author

Abstract- The main objective of the project is to analyze and simulate a steel frame using ANSYS software to determine how stresses and deformation vary with temperature. An approximation method is used to accurately represent the non-uniform temperature distribution within a portion of a 3d beam structural finite element. With this method, the impact of temperature fluctuations on the structural behavior of the 3D members may be represented more accurately. The study aims to analyze the behavior of steel members under various heat conditions by examining the stress distribution and deformation patterns. The study showed that the deformation of the steel column at 500 °C was 0.0568m, while at 1000 °C, the maximum deformation was 0.1086 m. The maximum deformation of 0.1240m occurred at 1500 °C. When beams were exposed to 500 °C, 1000 °C, and 1000 °C, they also showed maximum deformation up to 0.066m, 0.1086m, and 0.2351 respectively. According to our modelling results, steel beams went through deformation, cracking, fracture, and ultimate failure as the temperature increased, which ultimately affected their load-bearing capacity. This study also establishes that the span length, loading magnitude, and cross-sectional properties of structural members influence fire resistance behavior.

Keywords- ANSYS, Steel Frame, Temperature

PREDICTING INITIAL STIFFNESS IN WELDED T-JOINTS FEATURING CHS CHORDS AND LONGITUDINAL THROUGH-PLATE CONNECTIONS

[a] Ali Ajwad*, [b] Massimo Latour

a: DICIV, University of Salerno, Salerno, Italy. aajwad@unisa.it
b: DICIV, University of Salerno, Salerno, Italy. mlatour@unisa.it
* Corresponding author

Abstract- In steel braced frames, connecting longitudinal plates to Circular Hollow Sections (CHS) can lead to low joint stiffness due to deformation of the tube face, often requiring thicker members. To improve this, passing-through plate connections offer increased stiffness but lack predictive stiffness models in current codes and research. This study addresses that gap by developing stiffness formulations for CHS T-joints with axially loaded passing-through plates. Using validated finite element models and parametric analysis of 65 configurations, the proposed equations—based on simplified mechanical models—accurately predict initial stiffness of the connection, having a mean prediction ratio of 1.01 and the coefficient of variation equal to that of 7%.

Keywords- Passing-Through Longitudinal Plate, Circular Hollow Section Profile, Regression Analysis, FEM, Abaqus

BRIDGE EXPANSION JOINTS REPLACEMENT CHALLENGES – A REVIEW

[a] Mustafa Zwain, [b] Furqan Qamar*

a: Graduate Engineer WSP UK, Mustafa.Zwain@wsp.com
b: Associate Director WSP UK, Furqan.Qamar@wsp.com
* Corresponding author

Abstract- Bridge expansion joints play a critical role in maintaining the structural integrity, functionality, and serviceability of bridges by accommodating movements caused by thermal fluctuations, shrinkage, creep, and dynamic loading. However, due to their exposure to harsh environmental conditions and repeated traffic loads, expansion joints are prone to accelerated deterioration, often necessitating repair or replacement well before other bridge components. The replacement of expansion joints presents a unique set of challenges that extend beyond simple component substitution. These challenges encompass design issues, such as ensuring compatibility with ageing structures, recalculating movement ranges under modern codes, and selecting appropriate joint types, as well as construction challenges including unexpected services, poor bridge deck or abutment conditions, adverse weather impacts, and health and safety risks. This paper provides a comprehensive review of the multifaceted challenges associated with bridge expansion joint replacement, drawing upon current literature, case studies, and practical engineering experience. It highlights the importance of proactive investigation, strategic design decisions, and effective collaboration between designers and contractors to mitigate risks and ensure durable, cost-effective solutions. By addressing both design and construction aspects holistically, this review aims to support practitioners in developing resilient maintenance strategies for bridge infrastructure, ultimately contributing to improved asset longevity and reduced life-cycle costs. The review also identifies a critical gap in knowledge transfer practices and calls for the development of industry-wide mechanisms to capture and share field-level insights from replacement projects.

Keywords- Expansion Joints, Design Challenges, Construction Challenges, Joint Replacement, Structural Durability

NUMERICAL BEHAVIOR OF STEEL SPACE FRAME UNDER INCREMENTAL SEISMIC LOADS

[a]Kamran Shaukat*, [b]Muhammad Fahim

a: Department of Civil Engineering, UET Peshawar, Peshawar, Pakistan. cekamranshaukat@gmail.com
b: Department of Civil Engineering, UET Peshawar, Peshawar, Pakistan. drfahimuet@gmail.com
* Corresponding author

Abstract- Space frames are structural systems composed of linear elements arranged in a three-dimensional configuration to efficiently transfer loads. However, they exhibit complex dynamic behavior during earthquakes, particularly in seismically active regions such as Japan, China, and the United States. Notably, the 2013 Lushan earthquake caused severe damage to multiple structures, including three gymnasiums with space frame roofs. The destruction and collapse of long-span spatial structures are usually due to the large plastic deformation of the members. How to avoid bending and buckling due to the damage of the member under earthquake load is the key point in the design. This study investigates the elastic and plastic response of space frames using the finite element software ABAQUS. The structural model is assumed to be located in Abbottabad, Pakistan, a region with notable seismic activity. Incremental Dynamic Analysis (IDA) of a space frame was performed under the Chi-Chi (1999) earthquake record with progressively increasing intensity levels. Yielded Element Ratios and integration point evaluations was used to assess the yielding of members and section points. The findings provide a better understanding of how space frames behave under incremental seismic loads and give a brief understanding of performance-based design of space frames.

Keywords- Incremental Dynamic Analysis, Seismic Response, Space Frame, Yielding Behavior

SEISMIC RESISTANT BUILDINGS USING DAMPERS: A COMPARATIVE STUDY

[a] Muhammad Bilal Ansari*, [b] Muhammad Yaqub

a: Department of Civil Engineering, University of Engineering and Technology Taxila, Pakistan. engr.mbilalansari@gmail.com
b: Department of Civil Engineering, University of Engineering and Technology Taxila, Pakistan.muhammad.yaqub@uettaxila.edu.pk
* Corresponding author

Abstract- This study evaluates the comparison of the seismic behavior of reinforced concrete buildings of varying heights (G+14, G+29, and G+44), both with and without the inclusion of viscous dampers. The building under consideration is situated in Islamabad and falls under seismic site class "C". It features a regular square layout and is intended for residential use. All structural components are designed in accordance with ACI 318-15 standards, while the applied loads are determined based on IBC-2023 provisions. The structural system adopted is a special reinforced concrete moment-resisting frame. For dynamic analysis, the response spectrum method has been utilized. Both the structural modeling and analysis has been performed using ETABS version 17.0.1. Given that earthquakes are among the most significant natural hazards globally, this study incorporates viscous dampers to mitigate the seismic response of the structure. The dampers are employed in high rise structures in seismic zones to minimize vibrations caused by lateral stresses. Such as strong winds and earthquakes in order to prevent such catastrophic damages. The mechanical properties of the viscous damper employed in this study include a damping coefficient Cd=320 KN/ (mm/s) and a stiffness value Kd=224 KN/mm. Key structural response parameters such as storey drift, storey shear, storey displacement, and storey stiffness are evaluated and compared.

Keywords- ETABS, Seismic Response, Storey Drift, Viscous

SEISMIC CAPACITY ENHANCEMENT OF STONE MASONRY BUILDINGS USING HORIZONTAL TIMBER ELEMENTS

[a]Waqas Khan, [b]Muhammad Fahim*

a: Civil Engineering Department, UET Peshawar, Peshawar, Pakistan. hawaiuet@gmail.com
b: Civil Engineering Department, UET Peshawar, Peshawar, Pakistan. drmfahim@uetpeshawar.edu.pk
* Corresponding author

Abstract- Stones and timber are the natural materials found abundantly in the Northern hilly areas of Pakistan and many other countries of the world. Human beings have used them for centuries to make houses for providing shelter against natural and environmental hazards. Bhatar is one such typical construction in which stone masonry walls are divided into panels by providing horizontal timber elements. The timber elements are cross braced at intervals along the length and anchored with orthogonal walls at the corners. Its performance in past earthquakes has been good, which was once again demonstrated in the Kashmir earthquake of October 8, 2005. This study presents the results obtained from shake table test of a reduced scale model of Bhatar construction. The results obtained can be used to evaluate the seismic capacity of these structures

Keywords- Bhatar Construction, Stone Masonry, Seismic Resistance, Shake Table, Timber Bands

COMPARING CONSTRUCTION PROJECT MANAGERS AND MILITARY OFFICERS IN THE UNITED STATES: LEVERAGING VETERAN LEADERSHIP AND SKILLS FOR WORKFORCE DEVELOPMENT IN THE CONSTRUCTION INDUSTRY

[a] Amna Salman*, [b] Gavin Medley

a: McWhorter School of Building Science, Auburn University, Auburn, AL., USA. azs0072@auburn.edu
b: McWhorter School of Building Science, Auburn University, Auburn, AL., USA. gnm009@auburn.edu
* Corresponding author

Abstract- The construction industry faces growing demand for skilled project managers, while transitioning military veterans offer valuable leadership and problem-solving skills essential for this sector. However, veterans encounter barriers in translating military experience into civilian careers, including employer perceptions about skill transferability. This study compares job functions and skills of military officers with those required of construction project managers in the United States to evaluate transferability and inform transition strategies. Through qualitative interviews, our research revealed significant alignment in core competencies such as leadership, communication, coordination, problem-solving, and resource management. Findings indicated that while military officers possess these foundational skills, they often lack construction-specific technical knowledge and industry terminology. Primary transition challenges stemmed from cultural differences, unfamiliarity with industry regulations, and difficulties adapting leadership styles to civilian workplaces. Recommended interventions include targeted technical training programs, industry-specific mentorship networks, employer awareness initiatives, expansion of transition programs like Department of Defense (DOD) SkillBridge, and development of tools translating military experience into industry-recognized language. These strategies will facilitate integration of military talent into construction management, addressing industry workforce needs while supporting veterans' successful career transitions.

Keywords- Veteran Employment, Military Transition, Construction Management, Skill Transferability

IMPACT OF MIXED REALITY TECHNOLOGY ON TEACHING AND LEARNING IN STRUCTURAL ENGINEERING

[a] Guangyan Shao, [b] Salman Azhar*, [c] Busra Yucel

a: McWhorter School of Building Science, Auburn University, Auburn, Alabama, USA. sza0001@auburn.edu
b: McWhorter School of Building Science, Auburn University, Auburn, Alabama, USA. salman@auburn.edu
c: McWhorter School of Building Science, Auburn University, Auburn, Alabama, USA. bzy0027@auburn.edu
* Corresponding author

Abstract- This study investigates the impact of Mixed Reality (MR) technology on teaching and learning outcomes in structural engineering education. Specifically, it examines how MR enhances students' comprehension, engagement, and efficiency when learning about complex structural assemblies compared to traditional pedagogies based on 2D drawings. Participants were divided into two groups: one used conventional 2D drawings, while the other interacted with MR models via Microsoft® HoloLens 1.0. Both groups completed identical assessments measuring understanding and task completion time. Although the average quiz scores were similar (61%), the MR group completed tasks 17% faster and demonstrated more consistent performance. Qualitative feedback revealed that students valued MR's immersive and interactive experience, which helped them visualize and understand structural relationships more effectively. However, concerns were noted regarding device cost and physical discomfort. Overall, the findings highlight MR's potential to improve structural engineering instruction by enhancing spatial comprehension and learner engagement, suggesting promising directions for future integration into engineering curricula.

Keywords- Building Structures, Structural Engineering Education, Learning Efficiency, Mixed Reality

BIM-DRIVEN ENERGY OPTIMIZATION: ENHANCING THERMAL PERFORMANCE OF BUILDINGS IN ISLAMABAD'S CLIMATE

[a] Shujahat Anwar, [b] Hassaan Bin Raheel*

a: Civil Engineering Dept., National University of Technology, NUTECH, Islamabad, Pakistan. Shujahatanwar55@gmail.com
b: Civil Engineering Dept, National University of Technology, NUTECH, Islamabad, Pakistan. Hassaanraheel01@gmail.com
*Corresponding author

Abstract- In contemporary architecture, energy efficiency is a key design consideration due to increasing operational energy demands and environmental concerns. Contrary to the common belief that construction costs dominate a building's lifecycle expenses, operational energy and maintenance costs impact long term sustainability. In Islamabad, a city with composite climate featuring hot summer and cold winters, poorly designed buildings often rely on HVAC systems, resulting in higher energy usage and carbon emissions. This study employs Building Information Modeling (BIM) tools, specifically Revit and Insight, to analyze and optimize the energy performance of the NIEC lab which is under construction at NUTECH University. The model incorporates real climatic data and material properties to assess how heat transfer mechanisms affect thermal efficiency. Simulation results an initial Energy Use Intensity (EUI) of 271 kWh/m²/year, which was reduced by 58% through strategic modifications, including shading devices, window glazing, and building orientation. This paper further explores the integration of renewable energy systems, such as photovoltaic panels and small wind turbines, as potential solutions for reducing grid dependency. These findings offer practical recommendations for designing thermally efficient, cost-effective and sustainable buildings tailored to Islamabad's climate.

Keywords- BIM, Energy Efficiency, Heat Transfer, Sustainable Building Design

CLASH DETECTION OPTIMIZATION IN BIM: A CASE STUDY ON COORDINATION AND DESIGN EFFICIENCY IN INFRASTRUCTURE PROJECTS

[a] Muhammad Aqib Jahangir*, [b] Umar Farooq, [c] Asim Sultan

a: Civil Engineering Dept., National University of Technology, NUTECH, Islamabad, Pakistan. aqibjahangirf21@nutech.edu.pk
a: Civil Engineering Dept., National University of Technology, NUTECH, Islamabad, Pakistan. umarfarooq02f21@nutech.edu.pk
b: University of Rasul, Mandi Bahauddin, Pakistan. asimsultan@putrasul.edu.pk
* Corresponding author

Abstract- This Paper presents a methodology for Building Information Modeling (BIM) based clash detection, with a focus on a case study of the National University of Technology Admin Block in Capital Smart City, Islamabad. We detailed standardized modeling protocols, precise Levels of Detail (LOD), clash detection criteria, and structured resolution workflows to optimize interdisciplinary coordination. Using Autodesk Revit for individual discipline models (architectural, structural and MEP) and Navisworks Manage for clash detection, we identified 1,344 hard clashes at a 0.003 ft tolerance. Detailed quantification of clash penetration depths (ranging from 0.479 ft to o.664 ft) and spatial clustering analyses guided targeted resolution efforts. We compare our findings against benchmarks from similar infrastructure projects, demonstrating that early, rigorous clash detection reduces downstream rework relative to traditional workflows. Based on project findings, we propose a practical framework comprising modeling standards, naming conventions, phased review cycles and prioritized resolution to guide local and regional firms in infrastructure projects. A critical literature synthesis, clear definitions of technical terms and a discussion of limitations, challenges and future research directions are included to strengthen the paper's contribution to both academia and practice.

Keywords- Building Information Modeling (BIM), Clash Detection, Autodesk Revit, Navisworks Manage

COST–BENEFIT ANALYSIS OF BIM IN LARGE INFRASTRUCTURE PROJECTS: PAKISTAN VS GERMANY

[a] Chaudhry Muhammad Shahram Akbar, [b] Muhammad Ziyad, [c] Mohammad Qasim Bilal*

a: NUST Institute of Civil Engineering, NUST, Islamabad, Pakistan. shahramkhan056@gmail.com
b: NUST Institute of Civil Engineering, NUST, Islamabad, Pakistan. muhammadziyad2345@gmail.com
c: NUST Institute of Civil Engineering, NUST, Islamabad, Pakistan. engr.qasim.bilal@gmail.com
* Corresponding author

Abstract- Building Information Modeling (BIM) is transforming design and construction by enabling integrated 3D models and collaborative workflows. In Germany, government mandates and industry initiatives have driven widespread BIM adoption (~70% of firms), whereas in Pakistan, BIM remains nascent (~11% adoption). This paper reviews recent evidence on BIM's economic and technical outcomes in building-type infrastructure projects in both countries. Studies consistently show that BIM can improve design quality and reduce errors, which translates into cost and time savings. For example, clash detection alone can save up to 10% of contract costs and shorten schedules by ~7% [5]. In Pakistan, stakeholders report that BIM could reduce project cost and time by up to 57% when properly implemented, even though current adoption is low and often limited to 3D drafting. In Germany, early adopters and public infrastructure programs anticipate more modest but reliable savings (on the order of 5–10%) due to higher baseline efficiency. Overall, BIM's benefit–cost profile tends to be positive once initial training and software costs are amortized, with the German government projecting industry-wide productivity gains and lifecycle efficiencies from its 2025 BIM mandate.

Keywords- Building Information Modeling, Cost-Benefit Analysis, Economic Analysis, Infrastructure Projects

SPATIAL DOWNSCALING OF GRACE DATASET USING RANDOM FOREST APPROACH FOR A BETTER UNDERSTANDING OF HYDROLOGICAL DROUGHTS IN PAKISTAN

[a] Mustajab Ali, [b] Usman Ali*

a: Department of Civil Engineering, Mirpur University of Science and Technology (MUST), Mirpur Azad Kashmir, Pakistan.
mustajab.ce@must.edu.pk
b: Department of Civil Engineering, Mirpur University of Science and Technology (MUST), Mirpur Azad Kashmir, Pakistan.
aliu70536@gmail.com
*Corresponding author

Abstract- Climate change and increasing urbanization along with anthropogenic activities has intensified the risk of hydrological droughts in a water stressed country like Pakistan. The overall goal of this study; i) to create a Random Forest machine learning framework to downscale GRACE based Terrestrial Water Storage Anomalies (TWSA) from 1° down to 0.25° spatial resolution, and ii) to assess drought frequency and intensity in various regions of Pakistan using an enhanced Terrestrial Water Storage dataset and the TWS-Drought Severity Index (TWS-DSI). A high-accuracy Random Forest model (R^2 = 0.9967) was trained on 1° resolution TWSA data and applied to finer resolution inputs to derive 0.25° TWSA estimates. The downscaled dataset revealed a sharp decline in water storage from 2011 onwards, with extreme drought conditions (TWS-DSI ≤ –1.6) observed post-2020 in regions such as Sindh and southern Punjab. The results obtained highlight the possibilities of ML being used for hydrological monitoring as well as the necessity of cohesive water resources planning that promotes Sustainable Development Goals 6 (Clean Water) and 13 (Climate Action).

Keywords- GRACE, Hydrological Droughts, Random Forest, TWSA, Pakistan

MECHANICAL AND MICROSTRUCTURAL ENHANCEMENT OF EXPANSIVE SOILS VIA SUSTAINABLE WASTE GLASS POWDER AND FLY ASH BLENDS

[a] Muhammad Usama*, [b] Ubaid Ullah, [c] Muhammad Rauf

a: Department of Geodesy and Geoinformatics, Hamburg, Germany. ukhattak999@gmail.com
b: Department of civil Engineering, University of Wah, Wah Cantt, 47040, Pakistan. ubaidkhattak999@gmail.com
c: Department of civil Engineering, University of Wah, Wah Cantt, 47040, Pakistan. engr.roufktk@gmail.com
*Corresponding author

Abstract- Expansive soils, particularly high-plasticity clays, pose significant challenges for construction due to their low shear strength, poor compaction, and shrink-swell behavior. `. Conventional stabilizing methods, such as those using lime or cement, are often associated with high costs and significant environmental impacts. This study investigates the use of two industrial byproducts, waste glass powder (WGP) and fly ash (FA),as sustainable stabilizers for expansive soils. Laboratory tests were conducted using varying contents of WGP (5–30%) and FA (5–17%) to assess improvements in compaction, strength, plasticity, and swell potential. The optimal blend of 25% WGP and 11% FA yielded significant enhancements: UCS increased by 178% to 401.29 kPa, plasticity index reduced by 69% to 11.13%, swell potential dropped by 76% to 6%, and dry density increased to 1.92 g/cm³. Shear strength improvements were also observed, with the angle of internal friction rising by 103% to 35.94° and cohesion reduced to 9 kPa. SEM and XRD analyses confirmed the formation of dense cementitious compounds, validating the microstructural improvement. These findings indicate that WGP and FA provide a sustainable and cost-effective alternative for stabilizing expansive soils in civil engineering applications.

Keywords- Soil Stabilization, Waste Glass Powder, Fly Ash, Expansive Soils, High-Plasticity Clays, Sustainability

FINITE ELEMENT STUDY ON THE ROLE OF SAND RELATIVE DENSITY ON LATERAL LOAD DISTRIBUTION IN PILED RAFT SYSTEMS

[a] Hamad Khan*, [b]Qazi Khurshid Ahmad, [c]Abdullah Khan Jadoon

a: Department of Civil Engineering, UET Peshawar. 20pwciv5445@uetpeshawar.edu.pk
b: Department of Civil Engineering, GIK Institute of Engineering Sciences and Technology, Swabi. gcv2445@giki.edu.pk
c: Department of Civil Engineering, UET Peshawar. 20jzciv0405@uetpeshawar.edu.pk
* Corresponding author

Abstract- Combined Pile Raft Foundation (CPRF) has emerged as a widely adopted foundation system, particularly suitable for high-rise structures and sites with weak subsoil conditions. Previous research has extensively examined the influence of parameters such as pile spacing-to-diameter ratio, raft dimensions, and pile configurations on the load-sharing behavior of CPRF. However, the effect of relative density of sand on the lateral load contribution of piles and raft remains underexplored. This study presents a numerical investigation using small-scale CPRF models in *PLAXIS 3D*, a finite element software known for its capability in simulating soil–structure interaction. Relative density was modeled indirectly by varying the modulus of elasticity (E) and the internal friction angle (ϕ) of sand. The findings indicate that the raft's contribution to lateral load resistance increases with higher relative density, while the pile's share in lateral resistance decreases. Furthermore, both vertical settlement and horizontal displacement were observed to reduce as relative density increased. Specifically, settlement decreased by 71% (from 0.62 mm to 0.18 mm), and horizontal displacement reduced by 50% (0.40 mm to 0.2 mm). The shift in lateral load resistance from front piles to back piles was attributed to increased stiffness in the soil surrounding the rear piles. Understanding the role of relative density in CPRF systems can contribute significantly to their optimized and cost-effective design, reinforcing their potential as a sustainable foundation solution in geotechnical engineering.

Keywords- CPRF, Plaxis-3D, Finite Element Modelling (FEM), Relative Density

NUMERICAL ANALYSIS OF LATERALLY LOADED PILES IN FINE GRAINED SOIL

[a] Ahsan Raza Khan*, [b] Abdulllah Khalid

a: Department of Civil Engineering, The University of Lahore, Lahore, Pakistan. hafizark227@gmail.com
b: Department of Civil Engineering, The University of Lahore, Lahore, Pakistan. Abdullahkhalid7012@gmail.com
* Corresponding author

Abstract- Pakistan is located at the intersection of two plates i.e. Indian and Eurasian plates, had faced various devastated earthquakes in the past. After the catastrophic earthquake of 2005, a group of researchers, academician and practice engineers proposed revision in seismic provision and published Building Code of Pakistan (BCP) in 2021. BCP 2021 provides generic guidelines related to soil dynamics, however, doesn't address the soil-pile dynamic interaction explicitly. In this study, an effort is made to examine the behavior of laterally loaded large diameter piles constructed in Islamabad using numerical method, a framework proposed in already published research studies. Two numerical methods were employed and dynamic characteristics of pile is examined. The result indicated higher displacement at the top and at natural frequency of the pile. Similar trends were noticed for bending moment and shear force variation.

Keywords- Bending Moment, Winkler Model, Finite Element Method, Shear Force, Stiffness

EXAMINING FREQUENCY-DISPLACEMENT RELATIONSHIP OF PILES IN FINE GRAINED SOIL

[a] Muaaz Duera*, [b] Hamza Shabir

a: Department of Civil Engineering, The University of Lahore, Lahore, Pakistan. muaazdeura019@gmail.com
b: Department of Civil Engineering, The University of Lahore, Lahore, Pakistan. itshamza9282@gmail.com
* Corresponding author

Abstract- This research work focuses on the dynamic response of pile foundations subjected to lateral loading in fine-grained soil by employing Winkler Beam-Spring Foundation model (WBSF) with a Reduced-Dimension Finite Element Model (RDFEM). Three pile diameters (0.76m, 1.2m, 2.0m) were selected for the analysis. The results noted that the WBSF model consistently predicted 20-30% greater displacements and lower natural frequencies) due to its simplified spring-based soil representation. On the contrary, the RDFEM model predicts higher excitation frequencies and reduced displacements as it corporates 3D soil continuity, yielding more realistic soil-pile dynamic interaction. These findings align with already published research, demonstrating that WBSF serves for preliminary analysis, and its limitations in capturing true soil-pile interaction make it unsuitable for critical dynamic loading cases. The RDFEM gives higher accuracy, particularly in simulating seismic effects and soil yielding, provides essential insights for safe foundation design. This work highlights the necessity of advanced modeling techniques for reliable prediction of pile behavior in fine-grained soils subjected to lateral loads, offering practical guidance for geotechnical engineering practice.

Keywords- Pile Foundation, Dynamic Loading, Winkler Method, Pile Response Spectrum

ECO-FRIENDLY SOLUTION FOR UTILIZATION OF RECLAIMED ASPHALT PAVEMENT MATERIAL

[a] Hamza Afzal*, [b] Imran Hafeez

a: Civil Engineering Department, University of Engineering and Technology, Taxila, Pakistan. engr.hamza38@gmail.com
b: Civil Engineering Department, University of Engineering and Technology, Taxila, Pakistan. imran.hafeez@uettaxila.edu.pk
* Corresponding author

Abstract- Although Reclaimed Asphalt Pavement (RAP) is commonly used in road construction, research on its detailed laboratory and field performance is still limited. This study focused on evaluating the fundamental properties of RAP and identifying the optimal content for sustainable asphalt mixtures through a two-phase experimental approach. Key performance aspects such as rutting, cracking resistance, and moisture susceptibility were assessed. Results indicated that mixtures containing 40% RAP achieved the best balance of durability and sustainability. The Cooper wheel tracking test showed rut depths under 2.5 mm after 10,000 cycles, and the SCB test confirmed good fracture resistance at various temperatures. Moisture tests, including rolling bottle and boiling water methods, showed strong binder-aggregate adhesion with coverage above 85%. These findings suggest that with proper design, RAP can enhance pavement performance, reduce environmental impact, and lower the need for virgin aggregates by up to 40%.

Keywords- Fracture Resistance, Recycled Asphalt Pavement, Permanent Deformation, Moisture Damage

ASSESSING THE ENVIRONMENTAL IMPACT OF BUILDING MATERIALS: A LIFE CYCLE APPROACH TO SUSTAINABLE BUILDING SOLUTIONS

[a] Ruqia Asad, [b] Fayyaz Ullah*

a: Research Student, Civil Engineering Department, UET, Peshawar, Pakistan. 20pwciv5406@uetpeshawar.edu.pk
b: Research Student, Civil Engineering Department, UET, Peshawar, Pakistan. 20pwciv5563@uetpeshawar.edu.pk
* Corresponding author

Abstract- Climate change, driven by carbon emissions and greenhouse gases, is a major global challenge. In Pakistan, rapid urbanization and growing construction activities are key contributors to these emissions, further intensifying global warming. Cement production is one of the most emission-intensive processes, making the need for sustainable construction practices critical. This research explores the Life Cycle Assessment (LCA) of building materials used in affordable housing in Pakistan, focusing on identifying eco-friendly alternatives to reduce carbon footprints. Using a single-story residential unit in Peshawar as a case study, this research quantifies the embodied carbon emissions associated with traditional construction materials. Results demonstrate that alternative materials like rammed earth bricks, fly ash, and blast furnace slag significantly reduce carbon emissions compared to conventional materials. Scenario-based analysis shows that up to 70% reductions in carbon emissions are possible by integrating these sustainable materials into construction practices, highlighting the potential for low-carbon affordable housing in Pakistan. This study contributes to the Sustainable Development Goals (SDGs) by providing practical solutions for reducing carbon emissions in the construction industry.

Keywords- Life Cycle Assessment (LCA), Sustainable Construction, Climate Change, Carbon Emissions

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PERFORMANCE ANALYSIS OF LIGHTGBM, XGBOOST, RANDOM FOREST, AND GRADIENT BOOSTING IN PHOTOVOLTAIC ENERGY FORECASTING WITH HYPERPARAMETER OPTIMIZATION

[a]Muhammad Ehtsham*, [b] Marianna Rotilio, [c]Federica Cucchiella

a: Department of Civil, Construction-Architectural and Environmental Engineering, University of L'Aquila, 67100 L'Aquila, Italy.
muhammad.ehtsham@graduate.univaq.it
b: Department of Civil, Construction-Architectural and Environmental Engineering, University of L'Aquila, 67100 L'Aquila, Italy.
marianna.rotilio@univaq.it
c: Department of Industrial and Information Engineering and Economics, University of L'Aquila, 67100, L'Aquila, Italy.
federica.cucchiella@univaq.it
* Corresponding author

Abstract- Accurate photovoltaic (PV) energy forecasting is crucial for effective grid integration and for predictive usage at residential and industrial levels, especially under increasing climatic variability. This study evaluates and compares four machine learning (ML) models, LightGBM, XGBoost, Random Forest, and Gradient Boosting, for hourly PV energy forecasting using real-time data from numerical weather model (NWM), PVGIS, and historical production data from operational PV plant in Southern Italy. Three hyperparameter strategies, namely default settings, Optuna optimization, and Grid Search, were tested. Results show that LightGBM achieved the best performance with Grid Search tuning, yielding an MAE of 2.85 kWh, RMSE of 5.45 kWh, and R^2 of 0.71 over an 8-day forecasting horizon. Comparatively, XGBoost with Grid Search attained an MAE of 3.00 kWh, RMSE of 5.82 kWh, and R^2 of 0.67. The findings highlight that hyperparameter tuning significantly improved forecast accuracy and provide actionable insights for selecting ML models and optimization techniques in PV management systems. Findings are specifically of interest for practitioners, researchers, and organizations associated with PV management and operations.

Keywords- Gradient Boosting, LightGBM, Machine Learning, PV Management