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BOOK OF ABSTRACTS

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Foreword

Welcome to the CSCE 2026, 8th Conference on Sustainability in Civil Engineering (CSCE'26 – An international Conference) is held by Department of Civil Engineering, Capital University of Science and Technology, Islamabad, Pakistan. The main focus of CSCE'26 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 six wonderful and renowned keynote speakers for this edition of CSCE. We have received 115 manuscripts from different countries around the world including United States of America (USA), United Kingdom (UK), Canada, Luxembourg, Estonia, Italy, Australia, Turkey, China, Malaysia, Kingdom of Saudi Arabia (KSA), United Arab Emirates (UAE), Bangladesh, and Pakistan. All papers have under gone a comprehensive and critical review process. The review committee is comprised of 40 PhDs serving in industry and academia of United States of America (USA), United Kingdom (UK), Ireland, Poland, France, New Zealand, Australia, Malaysia, Singapore, Hong Kong, China, Oman, Kingdom of Saudi Arabia (KSA), United Arab Emirates (UAE), Bahrain, and Pakistan. After the screening and review process, 56 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

Conference Chair

CSCE'26


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

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Dr. Ana Armada Bras *Liverpool John Moores University, UK*	*Engineering a Future That Grows Itself - Bio-based Materials for Resilient Buildings & Structures*
Dr. Li Li *Northwest A&F University, China*	*Rheology of Geopolymer Grouting Materials*
Dr. Muhammad Noman *University of New Mexico, USA*	*Advancing Sustainable Construction through 3D Concrete Printing and LC3 Technology*
Dr. Muhammad Usman Arshid *The University of British Columbia, Canada*	*The Application of Remote Sensing in Civil Engineering*
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DEMOLISHED CONCRETE POWDER FOR SUSTAINABLE CONCRETE

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Abstract- The mounting demand for green building materials, especially in post-war and conflict-affected regions, has built up a need to recycle construction and demolition waste. This study investigates the viability of recycling demolished concrete powder (DCP) as a partial cement replacement. The study evaluates its effects on mechanical and physical properties. Concrete mixes with 0% 10%, and 30% DCP were tested for compressive strength, flexural strength, and non-destructive properties using Ultrasonic Pulse Velocity (UPV) and Schmidt hammer tests. The study is an extension of the previous work that evaluated 20% DCP as a cement replacement, by investigating lower and higher replacement levels (0%, 10%, and 30%). The 10% DCP mix maintained compressive strength comparable to the control at 28 days, likely due to the filler effect and improved particle packing that partially offset the cement dilution effect. However, flexural strength decreased with increasing DCP content, reflecting the sensitivity of tensile properties to cement reduction. The 30% DCP mix exhibited strength loss due to dilution of cementitious phases. Overall, DCP is viable up to 10% replacement, offering a sustainable solution for resource-efficient and resilient reconstruction in post-conflict environments.

Keywords- Demolished Concrete Powder, Density, Post-Conflict Reconstruction, Mechanical Strength.

PERFORMANCE OF WASTE FIBERS AND CARBON BLACK IN CEMENTITIOUS COMPOSITES: MECHANICAL STRENGTH, ELECTRICAL CONDUCTIVITY, AND PIEZORESISTIVE SENSING BEHAVIOR OF COMPOSITES

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Abstract- The piezoresistive sensing performance and mechanical behavior of cementitious composites incorporating carbon black grade N330 and recycled steel fibers (RSF) derived from end-of-life passenger tyre carcasses are investigated. CB N330 is fixed at 7.5% by weight of cement, while 18 mm RSF is introduced at four dosage levels by volume of the total mix, giving six mix designs in total. The mixes are tested for uniaxial tensile strength, 28-day compressive strength, electrical conductivity, and piezoresistive behavior under repeated cyclic compressive loading using the four-probe method. RSF transforms the brittle tensile failure of the control and CB-only mixes into progressive ductile fracture in all reinforced mixes, with the highest tensile strength about 102.0% above the control mix. A percolation threshold is established at a dosage of 0.50% by volume, at which both electrical conductivity and piezoresistive sensitivity reach their maximum values. The optimum sensing mix exhibits a quasi-linear response with a coefficient of determination R^2 of 0.9456. RSF additionally removes the FCR baseline drift present in the CB-only composite, supporting its dual function as a structural reinforcement and an electrical network stabilizer.

Keywords- Carbon Black, Cementitious Composites, Piezoresistivity, Recycled Steel Fibers, Structural Health Monitoring, Waste Tyres.

COMPRESSIVE STRENGTH AND DURABILITY OF CEMENTLESS PLASTIC-SAND PAVER BLOCKS INCORPORATING POLYPROPYLENE FIBERS

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Abstract-The growing burden of plastic waste and the environmental implications of cement manufacturing have led to an interest in the development of eco-friendly building materials. The study focuses on the preparation of sustainable cement less paver block with recycled high-density polyethylene (HDPE) as binder, sand as fine aggregate and polypropylene (PP) fibers as reinforcement. The grated HDPE was heated in an open pot to complete melting. Sand was then added and mixed thoroughly. Finally, polypropylene fibers were slowly added in order to achieve a homogenous mixture. Compressive strength tests were performed on various HDPE-to-sand ratios from 20:80 to 45:55 to find the best mix. However, the 40% and 45% HDPE based mixes that showed higher strength levels, were not workable, they formed many voids and were difficult to compress. Hence, the 30% HDPE and 70% sand mixture was considered as the best control mixture with the compressive strength of 11.02 MPa. Subsequently, 12 mm long PP fibers were added at rates of 0.3%, 0.6%, 0.9% and 1.2% by total weight. The addition of 0.6% PP fiber increased the compressive strength to 18.23 MPa. After optimum dosage, the strength decreased as a result of poor fiber dispersion and lower matrix-bonding. Freeze–thaw durability tests performed which showed satisfactory freeze–thaw resistance of the developed composites. The results reveal the potential of utilizing recycled HDPE with optimum content of PP fibers as an effective means to fabricate sustainable, low-cost, and cement-free paver blocks leading to plastic waste management, reduction of carbon emissions and eco-friendly construction practices.

Keywords- Cementless Paver Blocks, HDPE, Plastic-Sand Composite, Polypropylene Fiber, Sustainable Construction.

THE SIGNIFICANT EFFECT OF SILICA FUME ON COCONUT SHELL CONCRETE AS CEMENT REPLACEMENT

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Abstract- Concrete is the most widely utilised construction material for construction. The largest portion of the volume in concrete comes from the coarse and fine aggregate. The constant removal of aggregates from natural sources has raised costs and accelerated resource depletion. This study proposes the use of crushed coconut shells and silica fumes as replacements for aggregate and cement, respectively, to address the shortage of aggregate and the decarbonization of the environment. This study investigates the mechanical properties, durability (initial surface water absorption and carbonation resistance), and interfacial transition zone through microscopic examination of coconut shell concrete with 10% silica fume as a cement replacement. A microscopic examination was conducted to observe the bond between cement paste and coconut shells. 10% of silica fume as cement replacement has improved the strength of coconut shell concrete up to 20.3 N/mm^2. The durability of coconut shell concrete with silica fume is more reliable than coconut shell concrete itself since the coconut shell concrete has been filled with silica fume particles. Therefore, it was demonstrated that coconut shell concrete mixed with silica fume is an acceptable substitution for concrete.

Keywords- Coconut Shell Concrete, Lightweight Aggregate Concrete, Pozzolana, Sustainability.

THE COMPRESSIVE STRENGTH TEST OF CORE SPECIMEN EXTRACTED FROM BEAM AFTER ONE YEAR NATURAL WEATHERING

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Abstract- In this study, naturally weathered beam specimens were evaluated the mechanical performance of four different percentages of embossed Polypropylene fibers (0.30%, 0.40%, 0.50% and 0.60%) after long term exposure. Concrete cores were extracted from specific areas of the pre stressed beams, as per ASTM C42/C42M and tested under uniaxial compression. The compressive strength of the extracted concrete cores highest strength was obtained with the 0.40% polypropylene fiber-reinforced concrete. Furthermore, the load- deflection of curves and failure modes has been shown the differences in the deformation behavior and cracking characteristics of the extracted concrete cores with varying polypropylene fiber contents. After one year of natural weathering, the beam with 0.40% polypropylene fiber showed the highest core compressive strength among the fiber-reinforced beams.

Keywords- Polypropylene Fiber, Prestressed Concrete Beams, Core Extraction, Load-Deflection Behavior.

FIRE PERFORMANCE OF STAINLESS STEEL REINFORCED CONCRETE: A SHORT REVIEW

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Abstract- Stainless steel reinforced concrete (SSRC) is increasingly considered for durable and sustainable concrete infrastructure because stainless steel reinforcement offers corrosion resistance, high ductility and favourable mechanical-property retention at elevated temperature. However, fire performance of SSRC members has only recently begun to receive direct attention. This paper reviews the current evidence on SSRC fire behaviour, with emphasis on stainless steel reinforcement at elevated temperature, concrete degradation, bond and compatibility, finite element fire modelling, and the parametric trends reported for SSRC beams. The recent numerical study by Mehwish, Shamass and Cashell is treated as the main direct evidence because it developed and verified a finite element model for SSRC beams in fire, compared SSRC and conventional carbon steel reinforced concrete beams, and examined the effects of load ratio, reinforcement ratio and concrete strength. The review shows that SSRC beams can provide favourable fire resistance, partly because stainless steel retains useful strength and ductility at high temperature; however, the evidence base remains narrow and is dominated by numerical rather than experimental studies. The key gaps are direct fire tests on SSRC members, elevated-temperature bond-slip data, post-fire residual capacity assessment, reliability calibration and design guidance for different stainless steel grades. The paper concludes with practical modelling recommendations and a research roadmap for future work**.**

Keywords- Elevated Temperature, Finite Element Modelling, Fire Resistance, Reinforced Concrete, Stainless Steel Reinforcement.

SUSTAINABLE RECYCLED MATERIALS FOR POTHOLE REPAIR IN FLEXIBLE AND RIGID PAVEMENTS: A COMPREHENSIVE REVIEW

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Abstract- Potholes and localized pavement distress remain persistent maintenance challenges in flexible and rigid pavements because of moisture infiltration, repeated traffic loading, material aging, and climatic cycling. Conventional methods, including cold- and hot-mix asphalt patching, throw-and-roll repairs, and rapid-setting cementitious systems, often exhibit poor interfacial bonding, moisture susceptibility, inadequate early-age performance, shrinkage, and continued dependence on virgin materials. This review synthesizes recent literature on pothole and slab-distress mechanisms, evaluates established repair practices for both pavement types, and examines sustainable alternatives incorporating recycled and waste-derived constituents. For flexible pavements, systems combining reclaimed asphalt pavement (RAP), waste cooking oil (WCO), and recycled low-density polyethylene (rLDPE) show potential as lower-carbon substitutes for virgin hot-mix patches. For rigid pavements, rapid-repair concretes containing waste polyethylene terephthalate (PET) fibers, basalt fibers, or limestone calcined clay cement (LC^3) can improve selected mechanical and durability properties while diverting waste from disposal. However, wider adoption requires stronger evidence on patch-pavement bond durability, long-term field performance, constructability, and standardized mixture-design and testing procedures.

Keywords- Pothole Repair, Recycled Materials, Sustainable Pavement Maintenance, Reclaimed Asphalt Pavement, Rapid-Repair Concrete.

THE IMPACT OF GROUNDWATER INGRESS ON THE LONG-TERM STRUCTURAL INTEGRITY OF REINFORCED CONCRETE RETAINING WALLS - A REVIEW

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Abstract- This critically reviews the multifaceted failure mechanisms of reinforced concrete retaining walls subjected to groundwater ingress, bridging the gap between localized material degradation and global structural capacity loss. The novelty of this work lies in its integrated approach, dynamically linking chloride and sulfate-induced corrosion mechanics with shifting hydrostatic loads to evaluate the long-term efficacy of active versus passive remediation strategies. A comprehensive literature synthesis was conducted to analyze the physio-chemical breakdown of concrete matrices and the resulting escalation of lateral earth pressures. The study evaluated advanced non-destructive testing (NDT) methodologies, such as Ground Penetrating Radar (GPR) and Half-Cell Potential (HCP) mapping, for accurately diagnosing subsurface structural vulnerabilities. Furthermore, comparative assessments of structural retrofitting interventions, including Fiber Reinforced Polymers (FRP) and concrete jacketing, were analyzed alongside active groundwater management frameworks. The findings demonstrate that relying solely on passive waterproofing membranes is fundamentally inadequate under sustained hydraulic heads, inevitably leading to catastrophic sliding or overturning failures. To guarantee the extended service life of compromised subterranean walls, remediation must transition toward active hydrostatic pressure relief systems, such as exterior sump pits and perimeter drains. Ultimately, successfully restoring earth-retaining systems requires marrying robust structural retrofitting techniques with engineered active drainage infrastructure to permanently eliminate the underlying geotechnical loads.

Keywords- T-Junction, Interlocking Plastic Blocks, Mortar free Construction, Dynamic behavior, Sanp-back test, Fundamental Frequency.

AN OVERVIEW OF THE MECHANICAL PERFORMANCE OF HYBRID GLASS POLYPROPYLENE FIBER REINFORCED CONCRETE (HYGPFRC): A REVIEW

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Abstract- Concrete is the most widely used construction material globally, yet its inherently low tensile strength (8 to 15% of its compressive strength) and high susceptibility to cracking limit its structural performance without reinforcement. Fiber reinforcement has emerged as a proven strategy to mitigate these deficiencies. Among the available fiber types, alkali-resistant (AR) glass fibers and polypropylene (PP) fibers have attracted considerable research interest due to their complementary mechanical contributions and cost-effectiveness. This paper presents a comprehensive review of experimental studies published between 2015 and 2026 on the fresh state and hardened mechanical properties of glass fiber reinforced concrete (GFRC), polypropylene fiber reinforced concrete (PFRC), and their hybrid combination, designated as HyGPFRC. The reviewed evidence shows that glass fibers improve split tensile strength by up to 27% and flexural strength by up to 21% at optimum dosage, while PP fibers primarily enhance ductility, toughness, and early-age crack control. Recent studies confirm that hybridizing glass and PP fibers produces synergistic improvements of up to 17.1% in split tensile strength and 40.7% in flexural strength compared to plain concrete, consistently exceeding the performance of either fiber used alone. Key research gaps in the available literature are identified and future research directions are discussed.

Keywords- Glass Fiber, Hybrid Fiber Reinforced Concrete, Mechanical Properties, Polypropylene Fiber.

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EMERGING RECYCLED PLASTIC WASTES IN CEMENTITIOUS COMPOSITES: PERFORMANCE EFFECTS, LIMITATIONS, AND RESEARCH NEEDS

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Abstract- Globally, the uncontrolled surge in plastic waste has become one of the most critical environmental challenges of the 21st century, threatening ecosystems, human health, and the sustainability of natural resources. Although extensive research has examined conventional recycled plastics in construction materials, three emerging waste streams-e-waste plastics, face-mask polypropylene, and solar-panel polymers-remain largely underexplored in cementitious composites. This review critically synthesizes the available literature on the incorporation of these three recycled plastic waste types into cementitious composites and evaluates their effects on fresh properties, mechanical performance, durability, and microstructure. The findings indicate that these wastes can improve workability, reduce density, and enhance post-cracking ductility and toughness; however, reductions in compressive strength and weak interfacial bonding between the plastic and cement matrix remain important challenges. These materials therefore have strong practical potential as sustainable construction alternatives by diverting difficult waste streams from landfills while improving selected composite properties. Future research should prioritize long-term durability under aggressive environmental conditions.

Keywords- Recycled Plastic Waste, Cementitious Composites, Fiber-Reinforced Concrete, Mechanical Properties, Sustainable Construction

EFFECT OF HOOKED-END STEEL FIBER CONTENTS ON THE WORKABILITY AND MECHANICAL STRENGTH OF CONCRETE

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Abstract- The present study focussed at the effects of hooked-end steel fibres on the mechanical performance of concrete in its fresh and hardened state. Six concrete mixes were made which included a plain concrete as control specimen and five percentages of steel fibres of 0.55, 0.65, 0.75, 0.85 and 0.95 by volume of concrete. Workability of these mixes was evaluated based on slump value, while compressive and split tensile strengths of the hardened samples were measured using standard cylinders that had cured for 28 days. Fibre additions reduced workability because of the reduced mobility of the paste due to the presence of the fibres, since the slump values dropped from 72 mm in the control sample to 48 mm in the maximum dosage case. The compressive strength was marginally influenced, showing a maximum increase of around 14%, while there was considerable improvement in split tensile strength due to cracking bridging mechanism, increasing to nearly twice the control value at 0.75% fiber dosage.

Keywords- Steel Fibre-Reinforced Concrete, Hooked-End Steel Fibres, Optimum Fibre Dosage, Workability, Compressive Strength, Split Tensile Strength, Crack-Bridging

IDA-BASED SEISMIC FRAGILITY ASSESSMENT OF MID-RISE RC FRAME BUILDING IN ISLAMABAD, PAKISTAN

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Abstract- This research focuses on nonlinear seismic performance assessment and probabilistic fragility analysis of a four-story reinforced concrete moment resisting frame-resisting frame residential building in Islamabad, which was originally designed according to the Building Code of Pakistan 2007. A three-dimensional finite element model was created in SAP2000® that incorporated expected material strengths; moment hinges were lumped and calibrated using moment-curvature analysis. Seven ground motion records were selected from the PEER database and spectrally matched to the Building Code of Pakistan 2021 uniform hazard spectrum for Incremental Dynamic Analysis. Lognormal fragility functions were developed for Immediate Occupancy, Life Safety, and Collapse Prevention limit states using FEMA 365 guidelines. Performance assessment was conducted against the BCP 2021 Service Level Earthquake (SLE, 72-year return period), Design Basis Earthquake (DBE, 475-year return period), and Maximum Considered Earthquake (MCE, 2475-year return period) hazard levels. The results show the building meets minimum regulatory thresholds; however, at the Design Basis Earthquake level, an 85.3% probability of Immediate Occupancy exceedance indicates high damage vulnerability and reveals the seismic performance gap that exists when using BCP 2007-era residential construction standards under current code demands.

Keywords- Nonlinear Dynamic Analysis, Seismic Fragility Assessment, Islamabad, Residential Buildings.

SEISMIC PERFORMANCE OF LOW-RISE REINFORCED CONCRETE FRAMES ON ISLAMABAD SOILS CONSIDERING SOIL-STRUCTURE INTERACTION EFFECTS

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Abstract- In Pakistan, the conventional seismic design approach assumes that the foundation of a building is completely rigid and does not consider soil-structure interaction (SSI), which can lead to inaccurate estimates of the seismic demand on flexibly supported structures. The effects of SSI on a G+3 reinforced concrete moment-resisting frame located in the sector B-17, Islamabad, is evaluated using a fixed-base model compared to flexible-base models that have been used for three site classes (C, D and E) of ASCE 7-16 with shear wave velocities of 500 m/s, 250 m/s and 150 m/s respectively. A 2-D frame was designed in ETABS 2021 and analyzed using three earthquake records with their intensity scaled to the design basis earthquake (DBE) for Islamabad Zone 2B (S_s= 0.50 g, S_1 = 0.20 g) using nonlinear time history analysis. Following the guidance of NIST GCR 12-917-21, six-degree-of-freedom springs and dashpots were used to represent the foundation impedance as functions of frequency. The results indicate that compared to the fixed-base case, reduction in base shear ranges from 14.1% to 25.8%, and a reduction of base overturning moment ranges from 16.2% to 27.6%, whereas the roof displacement increases up to 93.1% and the maximum inter-story drift increases up to 65.4%. The drift limit of each flexible-base case is greater than that required by ASCE 7-16 (2.0%). The fixed-base case is just barely over that same limit. Under SSI the fundamental period extends from 0.412 s (for the fixed base case) up to 0.830 s and up to 1.162 s for SSI, respectively, due to the increased flexibility of foundation rocking. The results suggest that the fixed base analysis is non-conservative for drift-controlled design of low-rise frames with soft to medium Islamabad soils.

Keywords- Foundation Impedance, Inter-Story Drift, Nonlinear Time History Analysis, Soil-Structure Interaction

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DIVERGENCE IN DAMAGE-STATE THRESHOLD DEFINITIONS FOR NON-DUCTILE RC MOMENT FRAMES: EVIDENCE FROM A SYSTEMATIC LITERATURE REVIEW

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Abstract- Seismic fragility curves are governed directly by the damage-state thresholds used to define their underlying limit states, yet threshold definitions are rarely examined as an independent source of variability in fragility-based risk assessment. This study compares the damage-state threshold values reported across analytical fragility studies of non-ductile reinforced concrete moment frames identified through a three-stage systematic review of the published literature. At the first damage state, reported threshold values range from 0.25 to 0.80 percent interstorey drift ratio across studies of nominally equivalent structural systems, a more than threefold disagreement. A comparable range of 2.00 to 6.00 percent drift is observed at the threshold separating severe damage from collapse. The divergence does not segregate according to the source framework cited as the basis for the values, indicating that disagreement is not attributable to one or two dominant framework conventions. A threefold shift in value is also shown to occur within a single archetype when the assumed governing failure mechanism is altered, indicating that a meaningful portion of threshold variability is generated within individual analyses rather than across them. A further group of studies defines damage states for the same structural class through criteria not expressed in drift terms, adding a second layer of disagreement concerning the choice of demand parameter itself. The reported threshold values for non-ductile reinforced concrete moment frames are therefore not interoperable for direct comparison, aggregation, or reuse in seismic risk assessment without explicit harmonization of underlying threshold definitions.

Keywords- Damage-State Thresholds, Fragility Curves, Interstorey Drift Ratio, Non-Ductile RC Frames.

COMPARATIVE SEISMIC ANALYSIS OF A 10-STORY RC SHEAR WALL BUILDING IN PAKISTAN USING THE ELF METHOD

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Abstract- This study presents a comparative seismic performance evaluation of a ten-story reinforced concrete (RC) building system consisting of moment-resisting frames and shear walls in Islamabad, Pakistan. The structure is analyzed to assess the impact of evolving design standards, specifically contrasting the deterministic provisions of BCP 2007 with the updated probabilistic framework of Building code of Pakistan (BCP) 2021. Under BCP 2007, Islamabad is classified within Seismic zone 2B with a seismic zone factor of Z=0.20 for site class D. However, the implementation of BCP 2021 introduces a more site-specific representation of seismic hazard, defining the same site with significant spectral acceleration parameters (Ss=1.30, S1=0.38). To quantify the structural implications of this difference, the equivalent lateral force (ELF) method is employed using ETABS. Key response parameters, primarily inter-story drift and base shear, are evaluated and compared under both code provisions. The results indicate a substantial increase in seismic demand under the newer framework; specifically, inter-story drift increases by 137% and base shear increases by 152% under BCP 2021 compared to BCP 2007. These findings demonstrate a significant shift in seismic demand for Islamabad, highlighting the limitations of the previous uniform zoning approach. The transition to the probabilistic seismic design framework of BCP 2021 provides a more realistic, although more demanding, representation of seismic hazard, carrying critical implications for modern structural design practices in the region.

Keywords-Base Shear, Equivalent Lateral Force, Inter-Story Drift, Seismic Performance

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SEISMIC FRAGILITY CURVES OF RC BUILDINGS WITH COMMON CONSTRUCTION AND STRUCTURAL IRREGULARITIES IN DEVELOPING COUNTRIES

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Abstract- In developing countries, the vast majority of urban buildings are reinforced concrete (RC) multi-storeys, and much of this building stock was constructed with construction and configuration deficiencies that the modern seismic codes are designed to avoid. The aim of this study is to quantify such deficiencies and to increase the risk of collapse. Twenty-five archetype buildings were created, under five different heights configurations (four, six, eight, ten, twelve storeys) and under four configurations of deficient buildings depending on the deficiency: mass irregularity, soft story, material irregularity and torsional irregularity. The seven PEER NGA-West2 ground motions were applied to each model in ETABS using nonlinear direct-integration incremental dynamic analysis (IDA) with ASCE 41-13 plastic hinges hypothesized for the behaviour of each component. The fragility curves were modelled as lognormal functions at five performance levels (Operational through Collapse Prevention) and the fragility database was also checked with a machine learning surrogate in MATLAB. Vulnerability has been reported in terms of the median peak ground acceleration at each state and the probability that the entire model or model segment was failed as compared to its idealized counterpart. The results give a consistent order of severity. The worst deficiency is torsional irregularity causing a collapse capacity reduction of up to 47% and increasing the probability of failure to about 99% for RC frames. The least severe and lowest probability of failure is mass irregularity. The results point towards the correlation between these shortcomings, seismic collapse risk, and the ability of quantity and quality to be measured in an objective manner, suggesting that torsional deficiencies should be given the highest priority in the selection of seismic design and assessment procedures for RC structures in developing countries.

Keywords- Fragility Curves, Peak Ground Acceleration (PGA), Incremental Dynamic Analysis (IDA), Interstory Drift Ratio (IDR)

WIND LOADING OF NON-RECTANGULAR LOW-RISE BUILDINGS UNDER ASCE 7-22: A CRITICAL REVIEW OF CURRENT PROVISIONS, RESEARCH GAPS, AND FUTURE DIRECTIONS

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Abstract Determining wind loading is vital when designing low-rise structures, with ASCE/SEI 7-22 serving as the primary standard for calculating design wind pressures. But ASCE/SEI 7-22 wind provisions rely predominantly on rectangular building datasets, constrained to capture complex geometries (e.g., T-, L-, U-, C-shapes) aerodynamic behavior that trigger distinct torsional demands, uplift, and localized pressures. Grounded in recent studies, including Sarma et al.'s (2026) shape-factor model. This review synthesizes wind tunnel testing, Computational Fluid Dynamics CFD, field monitoring and analytical frameworks to highlight code deficiencies for irregular low-rise structures. It proposes a future roadmap, leveraging expanded datasets, high-fidelity Computational Fluid Dynamics CFD, machine learning, and geometry-specific design provisions.

Keywords- Aerodynamics, Artificial Intelligence, Computational Fluid Dynamics, Low-Rise Buildings

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COMPARISON OF SEISMIC ANALYSIS METHODS FOR REGULAR MID TO HIGH RISE REINFORCED CONCRETE STRUCTURES IN PAKISTAN

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Abstract- Accurate estimation of seismic demands is essential for the safe and economical design of reinforced concrete RC buildings located in earthquake-prone regions. Nonlinear Time History Analysis (NLTHA) is regarded as the most reliable method to assess seismic response, but for its application a high level of computational power, level of expertise and detailed nonlinear modelling is required. However, simplified analysis methods like the Equivalent Lateral Force (ELF) analysis, Response Spectrum Analysis (RSA) and Modified Modal Superposition Procedure (MMSP) are still very prevalent in engineering practice. But, the performance of these relative accuracy in Mid and High Rise RC building under the seismic conditions of Pakistan are insufficiently investigated. The performance of ELF, RSA and MMSP is presented and compared to the seismic demands predicted by the buildings based on the results obtained from the NLTHA, for three 20, 25 and 30 story regular reinforced concrete buildings in Islamabad, Pakistan. The comparison is based on the values of the displacement, story shear and overturning moment demands. The results show that the seismic demands of the structures are underestimated in every case for every building height, when using ELF and that the displacement results are underestimated, but are better than those from ELF, when using RSA. The story shear and overturning moment are closest to NLTHA in MMSP and reasonably captures higher mode effects which grow as a function of building height. The findings suggest that MMSP offers a practical and reliable alternative for estimating seismic demands of mid and high-rise RC buildings when detailed nonlinear analyses are not feasible.

Keywords- Reinforced Concrete Buildings, Time History Analysis, Response Spectrum Analysis, Modified Modal Superposition Procedure.

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SENSITIVITY OF CONCRETE DAMAGE PLASTICITY AND COHESIVE INTERFACE PARAMETERS IN NONLINEAR SEISMIC MODELLING OF CFRP-RETROFITTED INFILLED RC FRAMES

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Abstract- Nonlinear finite element models of CFRP-retrofitted infilled reinforced concrete (RC) frames are strongly affected by modelling parameters that cannot be measured directly from ordinary material tests. This paper presents a sensitivity-focused assessment of an integrated Concrete Damage Plasticity (CDP) and Cohesive Zone Modelling (CZM) framework used for seismic simulation of a textile-waste-core infilled RC frame strengthened with CFRP. The quantitative calibration record covers CDP viscosity, cohesive-interface penalty stiffness and frame-panel friction, while other CDP and CZM variables are screened through their expected physical mechanisms. A normalized sensitivity index and a ranked chart are used to compare the available response changes. Within the checked ranges, CDP viscosity produced less than 2% change in peak load and 2.1% in peak displacement; cohesive stiffness produced about ±12% change in peak load; and friction produced about ±18% change in cumulative energy dissipation while keeping peak-load change within about 4%. The ranking therefore identifies contact friction as the most influential quantified calibration parameter, followed by cohesive stiffness, with small CDP viscosity acting mainly as a numerical regularization parameter. Potential interactions between bulk damage, contact and interface parameters are discussed because one-factor-at-a-time screening cannot detect compensating or amplifying effects. A staged Abaqus calibration procedure is finally proposed using strength, stiffness, energy and local damage checks rather than peak resistance alone.

Keywords- CFRP Strengthening, Cohesive Zone Modelling, Concrete Damage Plasticity, Finite Element Analysis, Parameter Interaction, Parameter Sensitivity, Seismic Modelling.

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BLAST-RESISTANT REINFORCED CONCRETE STRUCTURES: A REVIEW OF NUMERICAL AND EXPERIMENTAL STUDIES

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Abstract- Buried reinforced concrete (RC) slabs are widely used in underground shelters, bunkers, tunnels, and protective infrastructure because of their ability to resist extreme dynamic loading. Surface-burst explosions generate intense blast pressures and shock waves that can cause excessive deformation, cracking, and even structural failure in such elements. This paper reviews the numerical and experimental research conducted on the blast response of reinforced concrete structures, with particular emphasis on buried and underground RC slabs subjected to surface-burst blast loading. Blast wave characteristics, material constitutive models such as Concrete Damage Plasticity, Johnson-Holmquist-2, and Riedel-Hiermaier-Thoma, and numerical blast simulation techniques, mainly the CONWEP approach implemented in ABAQUS and ANSYS-Autodyn, are discussed and compared. Studies on above-ground RC members, masonry walls, and underground tunnels are reviewed to identify the influence of parameters such as TNT charge weight, standoff distance, burial depth, soil stiffness, and boundary conditions on structural response. The review shows that while considerable research exists on blast-resistant above-ground buildings and underground tunnels, limited work has addressed the minimum required thickness of buried RC slabs under surface-burst loading based on performance-based design principles. The paper concludes by identifying these research gaps and proposing directions for future numerical investigation that incorporate soil-structure interaction and defined protection levels.

Keywords- Blast Loading, Buried Reinforced Concrete Slabs, CONWEP, Finite Element Modelling, Performance-Based Design, Soil-Structure Interaction, Surface-Burst Explosion.

RISK MANAGEMENT FRAMEWORK FOR SMALL DOD PROJECTS USING A CUSTOM RISK CALCULATOR

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Abstract- The U.S. Department of Defense (DoD) allocates a significant portion of its budget to the operation and maintenance (O&M) of its facility inventory. While large projects typically follow formal risk management practices, smaller efforts such as Sustainment, Restoration, and Modernization (SRM), O&M, and Job Order Contracting (JOC) often rely on informal approaches despite their growing volume and cumulative impact. This study investigates key risks contributing to delays, change orders, and cost inefficiencies in small DoD construction projects and proposes a structured approach to improve risk management practices. A mixed-methods approach was used, combining a literature review, semi-structured interviews with project delivery team members and contractors, and analysis of project data. The findings indicate that risk management in small projects is largely experience-driven and lacks standardized processes, with recurring issues related to unforeseen conditions, incomplete documentation, and scope definition. Based on these insights, a spreadsheet-based risk management calculator was developed to support early-stage risk identification and trade-specific analysis. The application of the tool is demonstrated through an anonymized case study of a small DoD renovation project, where it was used to identify, assess, and mitigate risks during scope development. The results show that structured risk assessment improves scope clarity, reduces uncertainty, and supports more informed decision-making. A generalized knowledge-sharing framework is presented to support broader implementation. Overall, the proposed approach offers a practical and scalable solution for improving consistency and performance in small DoD and similar construction projects.

Keywords- Construction Delays, Risk Assessment, Risk Calculator, Risk Mitigation, Small Projects.

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A COMPARATIVE ANALYSIS OF INTERNATIONAL STANDARD FORMS OF CONTRACT FOR DELAY MANAGEMENT AND FINANCIAL CLAIM DETERMINATION

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Abstract- Delays are a critical issue in global infrastructure projects, resulting in time over-schedules, financial claims and disputes. Extension of Time (EOT) and claim management systems are integral to Standard Forms of Contract (SFC) such as FIDIC, NEC and AIA; however, their efficacy is influenced by procedural philosophy and risk allocation. This research offers a comparative assessment of these contractual regimes in terms of the delay notification process, financial claim management and dispute resolution. This study employs a qualitative approach, combining clause analysis with empirical case studies, such as the 300-bed hostel (248 days' delay) and sewerage pipeline (49 days' delay). Results show FIDIC follows a reactive, compliance-based model with a focus on condition precedents, while NEC embraces proactive management with early warnings and compensation events. AIA adopts a design-focused decision-making approach. This study introduces a Comparative Evaluation Framework (CEF) for enhanced assessment of claims. The research aids in improving contractual efficiency in delay and financial claims management, especially for public projects. The main novelty of the paper lies in the establishment of CEF, which incorporates delay entitlement and cost claim assessment within a common decision support system.

Keywords- FIDIC, NEC, AIA, Delay Analysis, Extension of Time, Financial Claims

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BIM-BASED PROJECT MONITORING AND COST CONTROL MECHANISMS: A COMPARATIVE ANALYSIS

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Abstract- Building Information Modeling (BIM) has emerged as a transformative technology in the construction industry, offering unprecedented capabilities for project monitoring and cost control throughout the project lifecycle. Despite its growing adoption, a comprehensive comparative understanding of how different BIM-based cost control mechanisms perform relative to one another and relative to traditional approaches remains limited in the literature. This paper presents a systematic comparative analysis of BIM-based project monitoring and cost control mechanisms, examining 4D scheduling integration, 5D cost modeling, Earned Value Management (EVM) within BIM environments, real-time progress tracking, and automated quantity takeoff systems. Drawing upon an extensive review of peer-reviewed literature, industry case studies, and empirical project data from 2010 to 2025, the study benchmarks these mechanisms against conventional cost monitoring practices. Findings reveal that BIM-integrated cost control approaches consistently outperform traditional methods, reducing cost overruns by 15–25%, improving schedule adherence by up to 30%, and enhancing forecast accuracy significantly. Among BIM mechanisms, 5D BIM combined with real-time EVM tracking demonstrates the highest cost performance index improvement. The paper also identifies implementation barriers including cross-platform data exchange challenges, skill gaps, and initial investment thresholds. The comparative framework developed in this study provides practitioners and project managers with evidence-based guidance for selecting and deploying BIM-based monitoring strategies appropriate to project scale and complexity.

Keywords- BIM, Cost Control, Earned Value Management, Project Monitoring, 5D BIM, Construction Management.

DIGITAL COLLABORATION PLATFORMS FOR CONSTRUCTION STAKEHOLDER MANAGEMENT: ADVANCING SUSTAINABILITY IN PROJECT DELIVERY

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Abstract- Poor stakeholder coordination is one of the most persistent and costly problems in construction and one of the least discussed in sustainability research. This paper looks at how Digital Collaboration Platforms (DCPs), including BIM-based environments, cloud project management tools, and field communication systems, can address this coordination gap and, in doing so, meaningfully improve sustainability outcomes. Drawing on a review of the literature, the study traces three pathways through which DCPs contribute to sustainability: reducing rework and material waste, supporting better lifecycle decision-making, and broadening stakeholder participation in ways that strengthen the social dimensions of project delivery. A conceptual framework is proposed that maps DCP adoption onto stakeholder management processes and, ultimately, onto environmental, economic, and social sustainability outcomes. The framework is grounded explicitly in established stakeholder management theory rather than in coordination alone, is extended to cover emerging technologies such as artificial intelligence, digital twins, and block chain, and is paired with a set of measurable sustainability KPIs together with an illustrative validation against quantitative evidence already reported in the literature. The review also identifies where the research currently falls short, particularly the lack of empirical studies that connect specific platform features to measurable sustainability indicators, a gap this paper addresses in part by proposing concrete KPIs and benchmarks for future testing. The paper closes with guidance for practitioners on how to approach DCP adoption as a sustainability strategy, not just a productivity tool, and with directions for future research.

Keywords- Digital Collaboration, Stakeholder Management, Construction Sustainability, Building Information Modelling, Rework Reduction, Project Delivery

ARTIFICIAL INTELLIGENCE BASED PREDICTION OF STAKEHOLDER BEHAVIOR IN CIVIL PROJECTS

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Abstract- Stakeholder behavior has a direct impact on the success of civil engineering projects, particularly during the construction phase where multiple parties are involved and site conditions change frequently. When stakeholders are not managed well, it leads to conflicts, delays, and cost overruns. This paper presents an AI-powered chatbot developed to help engineers analyze and predict stakeholder behavior in construction projects. The user enters a site situation in plain language and the system returns a structured response covering stakeholder identification, predicted behaviors with probability estimates, risk assessment, and recommended actions. The chatbot was built using a generative AI model through the Groq API and deployed on the Hugging Face platform. A realistic multi-stakeholder construction delay scenario was used to validate the system. Results show that the chatbot correctly identified all stakeholders, predicted their likely behavior, assessed risks in a prioritized manner, and suggested practical actions. The study confirms that generative AI can serve as a useful decision-support tool for stakeholder management in construction.

Keywords- Generative AI, Decision Support System, Stakeholder Behavior, Construction Project Management

TOWARDS SUSTAINABLE DELIVERY OF EPC POWER PROJECTS IN EMERGING ECONOMIES: A HYBRID RISK ASSESSMENT APPROACH

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Abstract- Engineering–Procurement–Construction (EPC) power projects are essential for infrastructure development and energy security in emerging economies. However, their delivery is often hindered by contractual, financial, technical, regulatory, environmental, and social risks. This study proposes a Hybrid Risk Assessment Approach for the sustainable delivery of EPC power projects using IPP projects in Pakistan as the empirical context. A total of 42 risk factors were initially identified through a comprehensive literature review, of which 27 critical risks were retained for questionnaire survey after screening and refinement. From 220 distributed questionnaires, 182 valid responses were analyzed using Relative Importance Index (RII) to prioritize risks and Exploratory Factor Analysis (EFA) to identify the underlying risk dimensions. The findings revealed that contract ambiguities, payment delays, circular debt, inequitable risk allocation, and foreign-exchange exposure were the most critical risks. EFA classified the risks into five categories: Scope and Obligations, Financial and Payment, Technical and Operational, Regulatory and Policy, and Environmental and Social. The findings were further validated by industry experts and integrated into a Hybrid Risk Assessment Framework. The proposed framework provides a practical decision-support tool for improving risk management and enhancing the sustainable delivery of EPC power projects in emerging economies.

Keywords- Emerging Economies, EPC Power Projects, Risk Assessment, Sustainable Delivery

PYTHON-BASED FRAMEWORK FOR AUTOMATED MULTI-STAGE LCA OF GREEN CONCRETE

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Abstract- To align with United Nations Sustainable Development Goals (SDGs), Life Cycle Assessment (LCA) is becoming important in construction. Current methodologies often overlook the environmental benefits of green material substitutions, such as industrial and construction and demolition waste, focusing primarily on conventional constituents. This research presents a Python-based LCA application that automates carbon quantification using structural data exported from ETABS. By integrating validated emission factors sourced from renowned databases and peer-reviewed research, the tool enables the pragmatic application of lab-tested materials in the industry. The application categorizes emissions into distinct life stages: product manufacturing (A1–A3), transportation (A4), maintenance (B2–B5), end-of-life (C2–C4), and additional impacts (Module D). The framework was computationally verified using a previously published 10-story case study with 100% steel slag aggregate replacement. The framework yields a total cradle-to-grave emission of 3,073.59 tonnes CO_2 and a negligible deviation of −1.96% from the established benchmark, confirming model accuracy and directly supporting SDG 9 (Industry & Innovation), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action).

Keywords- Life Cycle Assessment, Carbon Reduction, Python, Green Concrete

MITIGATING HIDDEN COMMUNICATION FAILURES: A MULTIMETHOD FRAMEWORK TO DETECT AND RESOLVE THE SILENT RESISTANCE PHENOMENON IN PROJECTS

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Abstract- Effective communication is crucial for successful project management; however, various traditional and unconscious barriers erode this cooperative effort. This study explores the barriers to communication due to perceptual, digital, organizational and cultural factors. These factors cause an unaware psychological process between workers, known as the Silent Resistance Phenomenon (SRP), that undermines stakeholder engagement and their risk management capacity. Based on a comprehensive literature review, survey studies and qualitative interviews across various industries, this study identified the incidence and effects of SRP patterns. The results revealed that 64% of employees experienced SRP during project implementation, with perceptual biasness (38%) and digital misalignments (27%) as the most common causes, followed by organizational hierarchy (21%) and cultural differences (14%). Projects with SRP prevalence faced 32% more delays, 28% budget overruns, and 41% lower stakeholder involvement compared to low-SRP projects. Cross-cultural analysis indicated that multinational teams experienced 48% higher SRP incidence than identical teams. Pilot testing of the proposed AI-supported feedback system demonstrated a 22% rise in trust scores, 19% improvement in stakeholder engagement, and 17% reduction in communication barriers. This study is one of the contributions in conceptualizing and designing an AI-supported psychologically secure feedback system with anonymous sentiment-based feedback. This feedback uncovers latent resistance and enables evidence-based decision-making by allowing openness, trustworthiness and forward-looking cooperative work. This study addresses limitations of previous studies including sample heterogeneity, weak empirical foundation and lack of concern for cross-cultural communicative activity. The findings present a multimethod interdisciplinary program drawing upon real-time analytics and people-oriented communication theories. The outcomes resolve latent communicative breakdowns and facilitate project success in intricate organizational settings.

Keywords- AI-Based Feedback Systems, Project Communication Barriers, Sentiment Analysis, Silent Resistance Phenomenon, Stakeholder Engagement.

AI-DRIVEN AUTONOMOUS VISION FRAMEWORK FOR CONSTRUCTION-PHASE INSPECTION AND ENGINEERING LOCALIZATION OF MISSING PHOTOVOLTAIC MODULES IN LARGE-SCALE OFFSHORE PHOTOVOLTAIC SYSTEMS APPLICATIONS

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Abstract- Construction quality verification of ultra-large offshore photovoltaic (PV) installations presents significant challenges because thousands of platforms and millions of photovoltaic modules must be inspected before project commissioning. Conventional manual inspection is labor-intensive, time-consuming, and difficult to implement efficiently in offshore environments. This paper demonstrates the application of an AI-assisted UAV inspection approach for rapid construction-phase verification of offshore PV systems. High-resolution UAV RGB imagery was analyzed using a YOLOv8-based vision model, while geographic localization and grid-based spatial mapping were employed to associate detected missing modules with engineering coordinates. The proposed inspection workflow was evaluated using 2,800 UAV images collected from a 1 GW offshore photovoltaic project. The experimental results achieved a Precision of 100.00%, Recall of 96.15%, and an F1-score of 98.04%, with 96.83% agreement with manual inspection. In addition, the average processing time of 1.12 s per image demonstrates the feasibility of rapid inspection for large-scale engineering applications. The results show that integrating UAV remote sensing with AI-based computer vision can substantially improve construction quality inspection by providing efficient defect localization and engineering-oriented inspection records, thereby supporting intelligent quality management for large-scale renewable energy infrastructure.

Keywords- Artificial Intelligence; Autonomous Inspection; Deep Learning; Missing Photovoltaic Modules; Unmanned Aerial Vehicle (UAV); YOLOv8

MACHINE LEARNING-BASED ASSESSMENT OF BARRIERS AND AI ADOPTION IN THE CONSTRUCTION INDUSTRY OF PAKISTAN

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Abstract- This study investigates the integration of artificial intelligence (AI) and machine learning (ML) into the construction industry (CI) of Pakistan, addressing the sector's lag in adopting cutting-edge digital technologies despite a growing global trend toward intelligent automation and data-driven decision-making. Through a structured questionnaire survey, 450 multi-stakeholder responses were collected across seven critical domains to systematically identify and quantify adoption barriers, with technical and infrastructure constraints emerging as the most formidable (M=4.16), alongside critical issues such as limited data availability (M=4.42), poor digital infrastructure (M=4.38), and the absence of a national AI strategy (M=4.35). To overcome these analytical gaps, the study develops and rigorously validates a suite of predictive machine learning models, including ensemble methods (e.g., Random Forest, Gradient Boosting) and kernel-based algorithms (e.g., Support Vector Regression), which demonstrated exceptional predictive performance, achieving high testing accuracy and remarkably low root mean square error (RMSE), thereby confirming their robustness, generalizability, and superior capability in handling nonlinear, high-dimensional construction data. The validated framework not only provides a scientifically grounded decision-support mechanism for accelerating digital transformation but also offers actionable insights for policymakers and industry stakeholders to prioritize infrastructure upgrades, data governance, and skill development. Ultimately, this research bridges the gap between barrier identification and algorithmic solution design, presenting a reproducible, model-centric pathway for sustainable infrastructure development in resource-constrained developing economies

Keywords- Artificial Intelligence (AI), Machine Learning (ML), Construction Industry (CI), Predictive Modeling, Ensemble Learning, Kernel-Based Algorithms, Adoption Barriers, Digital Transformation, Developing Economies, Pakistan, Questionnaire Survey, Model Validation, RMSE, Sustainable Infrastructure.

LIFE CYCLE ASSESSMENT OF MULTIFUNCTIONAL CONCRETE INCORPORATING PUMICE AND PHASE CHANGE MATERIALS FOR SUSTAINABLE CONSTRUCTION IN PAKISTAN

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Abstract- Pakistan, as a developing country, is increasingly burdened by the dual challenges of urban infrastructure expansion and environmental degradation resulting from the construction industry. Cement-based concrete, being the most consumed construction material, contributes heavily to carbon emissions and resource depletion. To address these issues, this study proposes a novel multifunctional concrete mix incorporating pumice as a lightweight aggregate and paraffin-based phase change materials (PCM) for thermal regulation, aiming to reduce environmental load while enhancing performance. A Life Cycle Assessment (LCA) was conducted following ISO 14040 and ISO 14044 guidelines using SimaPro v9.5 and the Ecoinvent 3.10 database. A cradle-to-grave approach was adopted, assessing the environmental impacts of both conventional and multifunctional concrete. The ReCiPe 2016 Midpoint (H) method was used to evaluate 18 environmental impact categories, including global warming potential, human toxicity, resource scarcity, and ecotoxicity. Primary data for inventory modeling was collected from local construction industries in Pakistan and integrated into the LCA model. Results from characterization and normalization phases revealed that the multifunctional concrete achieved notable reductions in most impact categories-such as global warming, human carcinogenic toxicity, marine eutrophication, and mineral resource use-compared to conventional concrete. However, impacts related to fossil resource scarcity were found to be higher due to the petroleum-based PCM. Contribution analysis identified cement production and PCM encapsulation as the dominant contributors across most categories. The study concludes that the proposed concrete mix can significantly improve environmental performance, presenting a sustainable alternative for future construction in Pakistan.

Keywords- Life Cycle, Multifunctional Concrete, Pumice, Phase Change Material, Simapro, Recipe 2016, Environmental Impact.

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STATISTICAL ASSESSMENT OF TIME DELAY FACTORS IN BUILDING CONSTRUCTION PROJECTS

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Abstract- Time delay is one of the biggest issues faced in building construction projects, often causing cost escalation, resource idling, contractual conflicts, and loss of stakeholder trust. Based on 30 building construction projects, this conference paper introduces a pilot framework to determine the construction delay issues at the beginning. The factors that were responsible for delay were: unskilled labor, material delivery, cash flow, communication, scheduling practices, decision making, inflation and equipment performance were taken into the study. To ensure that the analysis is on a simple yet reliable statistical framework, the Relative Importance Index (RII) was first used to rank the delay factors identified based on the perceived importance level, followed by Chi-Square association analysis to explore the association's strength between the identified delay factors and the project delay status. The most critical delay factors identified from the RII analysis were based on the respondents' assessment, whilst the Chi-square test produced the factors that have the most significant link with a project delay. The findings show that using RII in conjunction with Chi-square analysis can be used to effectively identify and prioritize critical delay factors even in the absence of a large project-level dataset. The framework offered a practical context for contractors, consultants, and clients to assess delay in a construction project at an early stage and to make informed decisions, and also set the stage for future research with larger data sets and more extensive predictive methods to further enhance construction project performance.

Keywords- Chi-square analysis, Relative Importance Index, Building Projects, Time Delays

ASSESSMENT OF BARRIERS AND AI ADOPTION IN THE CONSTRUCTION INDUSTRY OF PAKISTAN

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Abstract- The developing economies' construction industry faces challenges in accessing cutting-edge technologies such as artificial intelligence (AI) due to infrastructure, financial, organizational, educational, and regulatory limitations, even though there is an emerging trend of intelligent automation and data-driven construction decision support systems. This study consists of the identification of adoption barriers to AI, statistical validation, and algorithmic performance in the construction industry (CI) of Pakistan, from 450 multi-stakeholder responses collected from seven critical domains. The most critical barriers identified in the use of AI in the construction sector in developing countries like Pakistan were technical and infrastructure barriers (M=4.16), with the least available data (M=4.42), poor digital infrastructure (M=4.38), and the lack of a national AI strategy (M=4.35).The outlined framework aims to create a scientifically validated decision support mechanism for the acceleration of digital transformation and sustainable infrastructure development in Pakistan's construction sector by integrating Artificial Intelligence (AI).

Keywords- Artificial intelligence, Construction industry, Developing countries, Pakistan's construction sector, Barriers.

EVALUATING THE POTENTIAL OF EGG SHELL POWDER AS A SUSTAINABLE AND COST EFFECTIVE ADDITIVE FOR EXPANSIVE SOIL STABILIZATION

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Abstract- Expansive soil is present in various regions of Pakistan and around the world. The construction of pavements and structures on expansive soil results in failure due to swelling and shrinking phenomena when it comes into contact with water. The complete removal of expansive soil increases project costs and makes the project uneconomical. Various waste products were used to stabilize the soil, which are produced in millions of tons nationwide each year. In the current research, eggshell powder (ESP) is used as a sustainable stabilizer for A-7-5 expansive soil. Systematic laboratory testing was conducted to assess the geotechnical performance of soils treated with different ESP proportions (1%, 2%, 3%, 4%, and 5%) by comprehensive evaluations of index properties and engineering properties. The experimental results showed that the addition of ESP significantly changed the physical and mechanical properties of soil. The liquid limit reduced continuously from 53.5% to 47.1% at 4% ESP content, and the plastic limit showed a similar decrease. Plasticity Index decreased from 19.0 to 17.1 within the ESP range of 1 to 4%, indicating improved workability and reduced swell potential. Compaction characteristics showed that maximum dry density decreased from 1.822 g/cc to 1.789 g/cc and OMC increased from 17.5% to 18.3% at 4% ESP, indicating better moisture retaining capability. Increasing ESP content from 0 to 4% resulted in significant improvements in California bearing ratio, from 0.5% to 1.3% at 90% compaction density and from 1.4 to 1.7 at 95% compaction density. Geotechnical properties of expansive soil, such as index properties, optimum moisture content (OMC), maximum dry density (MDD), and California bearing ratio (CBR), are improved by using eggshell powder as a stabilizer, and 4% ESP was found to be an optimum dosage for improving these properties.

Keywords- Soil stabilization, ESP, MDD, OMC, CBR.

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COMPARATIVE ASSESSMENT OF THE DYNAMIC RESPONSE OF PILES OBTAINED FROM WINKLER MODEL AND FINITE ELEMENT METHOD

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Abstract- Piles are a type of deep foundation that is mostly designed to resist axial loads. However, during their design life, piles have to resist significant lateral or vibrational loads coming from various sources of dynamic loading. In this paper, displacement spectra were generated for piles with varying diameters using two numerical methods, i.e., (i) Winkler Beam on Spring Foundation (WBSF) and (ii) Reduced Dimension Finite Element Method (RDFEM). The diameters measuring 0.5m, 1.0m, and 1.2m were used in the current study. The displacement response spectra obtained from the two numerical methods were compared. Notable differences in the displacement amplitudes and fundamental frequencies were observed between the two numerical methods. WBSF consistently predicts lower natural frequency and higher displacement values as compared to RDFEM. Resultantly, the results highlighted that the WBSF model underestimates the natural frequency of the soil-pile system, whereas it overestimates pile head displacement values. The discrepancies in the predictions by the WBSF model are primarily due to its simplification of representing soil as a series of 1D springs, ultimately ignoring shear interaction among the soil layers. On the contrary, the representation of the soil is more realistic in RDFEM, which yields a precise dynamic response of piles.

Keywords- Dynamic Response, Reduced Dimension Finite Element Method, Natural Frequency, Winkler Beam on Spring Foundation

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DYNAMIC SOIL-PILE INTERACTION – A COMPARATIVE REVIEW OF SOIL MODELING AND ANALYSIS APPROACHES

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Abstract- Dynamic soil-pile interaction plays a vital role in the prediction of the dynamic response of structures supported on piles. The soil-pile dynamics have been investigated employing various analytical, numerical, and experimental approaches. In the current paper, an effort is made to summarize the various soil modeling and analysis techniques well documented in the literature to understand the complex soil-pile dynamic mechanisms. The review includes both classical and advanced soil modeling techniques and categorizes the dynamic analysis into four types, including: (i) Winkler beam on Foundation Approach, (ii) Closed form solution, (iii) Finite element method, and experimental methods. Critical discussion is included in the paper with regard to the strengths and limitations of each analysis method. Based on the review and comparison of numerical methods with experimental techniques, it is concluded finite element method provides more precision and accuracy in the dynamic response of piles, whereas nominal discrepancies were observed in predictions obtained from Winkler modeling and analytical solutions.

Keywords- Dynamic Loading, Finite Element Method, Soil-Pile Interaction, Winkler Beam on Foundation Approach.

NUMERICAL INVESTIGATION OF THE DYNAMIC RESPONSE OF LATERALLY LOADED PILES USING WINKLER-BASED AND FINITE ELEMENT METHODS

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Abstract- In Pakistan, the response of piles to vibrational loading is not explicitly addressed. Building Code of Pakistan (BCP 2021) clearly suggests that site-specific response must be obtained in the regions close to an active fault zone on the basis of soil dynamic properties obtained from seismic cross hole test/down hole test. The present study investigates the variation of deformation, bending moment, and shear force along the length of the pile subjected to lateral vibrational loading. Three pile diameters measuring 0.5m, 1.0m, and 1.2m were considered, and the aforementioned parameters were obtained using two numerical methods, including (i) Winkler Beam on Spring Foundation (WBSF) and (ii) Reduced Dimension Finite Element Method (RDFEM). The results highlighted maximum deformation at the pile head and at the fundamental frequency of the piles in all three piles. Furthermore, predictions obtained by WBSF showed higher values as compared to RDFEM, which indicates that WBSF overestimates the pile dynamic response. The findings provide vital information and may assist engineers in investigating pile response to lateral load with comparable subsoil conditions.

Keywords- Dynamic Response, Finite Element Method, Natural Frequency, Winkler Beam on Spring Foundation

SUSTAINABLE STABILIZATION OF PEAT SOIL WITH TERRAZYME: LABORATORY STUDY

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Abstract- Peat soil possesses high water content, low dry density, and limited bearing capacity, which restrict its suitability for pavement and foundation applications. The present study evaluates the effectiveness of terrazyme in enhancing the compaction and strength properties of peat soil. Modified proctor tests were performed on both untreated and terrazyme-treated peat soil samples with varying stabilizer dosages to identify the optimum content. Untreated peat soil exhibited a maximum dry density (MDD) of 0.909 g/cc and an optimum moisture content (OMC) of 48.2%. Following stabilization with the optimum terrazyme dosage, the MDD increased to 1.13 g/cc, while the OMC decreased slightly to 47.5%, indicating improved particle packing and reduced moisture demand. Bearing capacity was assessed using soaked California Bearing Ratio (CBR) tests. The soaked CBR value increased from 0.83% for untreated peat soil to 1.35% for terrazyme-treated peat soil, representing an improvement of approximately 63%. This enhancement is attributed to the enzymatic action of terrazyme, which facilitates stronger soil particle bonding, reduces void spaces, and produces a denser soil matrix. These findings indicate that terrazyme is a promising stabilizer for improving the engineering performance of peat soil, although further treatment may be necessary for heavily loaded pavement applications.

Keywords- Peat Soil, Terrazyme, Soil Stabilization and California Bearing Ratio (CBR).

ASSESSMENT OF TRAFFIC SATURATION AND CAPACITY FORECASTING UNDER MIXED TRAFFIC CONDITIONS

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Abstract- Reliable estimation of saturation flow and capacity under mixed traffic flow conditions can be challenging for many developing countries where the traffic stream is very heterogeneous without a lane discipline. This paper aims to evaluate saturation flow rate, Level of Service (LOS) and traffic demand forecasting for the study corridor along N-125. Observed volumes were classified into their respective vehicle types and passenger car unit values were assigned after passenger car unit analysis. Traffic demand forecasting was carried out based on compound growth factor and capacity along with LOS was determined by HCM 2010 methodology. Trip generation rate was established using cross-classification method to evaluate travel demand. The study showed that traffic volume is continuously increasing from 2015 to 2036 with motorcycles being the highest vehicle type followed by cars. Based on the study the present volume/capacity ratio is 0.34 which clearly indicated LOS A (free flow); however, we will reach capacity sooner if no measures are taken.

Keywords- Capacity Analysis, Level of Service, Mixed Traffic, Passenger Car Unit, Traffic Forecasting, Trip Generation.

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EVALUATION OF CONVENTIONAL PROPERTIES OF MULTI-MODIFIED 60/70 BITUMEN USING MOLASSES, CRUMB RUBBER, WASTE COOKING OIL, AND POLYPHOSPHORIC ACID

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Abstract- The growing demand for sustainable pavements has intensified research into waste-derived binder modifiers that can improve performance while reducing environmental impact. This study examines the conventional properties of a 60/70 penetration grade bitumen modified with four additives, three of which are waste-derived: molasses (a bio-based, adhesion-supporting modifier), waste cooking oil (a rejuvenating and softening agent) and crumb rubber (a recycled elastomeric modifier), together with polyphosphoric acid, which is not a waste material but a chemical modifier used to increase stiffness, viscosity and softening point. Thirteen binder blends were prepared at incremental dosages and characterized through penetration, ductility, viscosity and softening point tests in accordance with the relevant ASTM standards. The results showed that waste cooking oil softened the binder and raised its penetration, whereas molasses, crumb rubber and polyphosphoric acid increased stiffness, viscosity and softening point. The optimum blend, containing 4% molasses, 6% crumb rubber, 2% waste cooking oil and 1% polyphosphoric acid by weight of bitumen, restored the penetration to approximately 61 dmm, comparable to the control, while raising the softening point from 53 °C to 61.1 °C, an increase of about 15%. The viscosity of this blend remained within the limit specified for adequate mixing and compaction, and although its ductility was reduced relative to the neat binder it remained adequate. The multi-modified binder is therefore better suited to higher service temperatures and offers a route to the sustainable reuse of three waste streams in road construction.

Keywords- Crumb Rubber, Molasses, Polyphosphoric Acid, Waste Cooking Oil.

MULTI-OBJECTIVE LEAST-COST PATH OPTIMIZATION FOR HAZARD-AWARE ROAD CORRIDOR PLANNING

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Abstract- Road corridors in seismically active, landslide-prone mountainous terrain are conventionally aligned to minimize construction cost and distance, often without a systematic, quantitative accounting of natural hazard exposure. This study develops a GIS-based multi-objective least-cost path (LCP) framework that treats terrain slope, land cover, seismic activity, and landslide susceptibility as independent cost dimensions rather than combining them through a single fixed weighting scheme. The framework was applied to a 58 km straight-line corridor of the Karakoram Highway (KKH) between Chilas and Jaglot, Pakistan, a segment situated at the tectonic convergence of the Himalayan, Karakoram, and Hindu Kush ranges. A composite cost surface was built from Copernicus GLO-30 elevation data, ESA WorldCover land cover, USGS historical earthquake records, and a slope-derived landslide susceptibility proxy. Least-cost paths were computed across 51 sampled weight combinations using a raster implementation of Dijkstra's algorithm, and the resulting candidate corridors were filtered to their Pareto-optimal subset. The actual KKH alignment was extracted from OpenStreetMap and evaluated against this Pareto front using the same four cost dimensions. Of 40 Pareto-optimal candidate paths, 11 achieved lower cumulative cost than the real alignment on every objective simultaneously, and the single best hazard-minimizing candidate eliminated cumulative exposure to both mapped seismic and landslide risk zones entirely, at the cost of roughly double the terrain-slope difficulty of the existing road. These results indicate that the real KKH alignment reflects a deliberate trade-off favoring construction feasibility over hazard minimization, a trade-off the proposed framework makes explicit and quantifiable rather than assumed.

Keywords- Karakoram Highway, Least Cost Path, Multi-Objective Optimization, Pareto Efficiency

MATERIAL DESIGN AND SELF-SENSING PERFORMANCE EVALUATION OF CONDUCTIVE ASPHALT CONCRETE

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Abstract- The transformative potential of self-sensing conductive asphalt concrete rests on a fundamental design challenge of achieving a delicate synergy between electrical conductivity and mechanical durability. This study explores the material composition and property optimization of conductive asphalt concrete using carbon fiber (CF) and iron tailing aggregates (ITA) as aggregate substitutes. As an industrial byproduct, ITA offers a sustainable alternative to natural aggregates while facilitating continuous conductive networks throughout the mixture. X-ray fluorescence and X-ray diffraction (XRF/XRD) analyses confirmed that ITA possesses an iron-rich composition. Experimental results revealed that a CF content of 0.2%–0.4% by weight of the asphalt mixture yields optimal conductive mixtures for critical performance evaluation. Moreover, electromechanical testing demonstrated that the resistance change response is mix composition-dependent. Among the formulations tested, the 0.4% CF/ITA mixture emerged as a particularly promising smart and sustainable system, combining robust mechanical properties with a sensitive and reversible electrical response under mechanical loading, thereby positioning it as a strong candidate for advanced self-sensing pavement applications.

Keywords- Carbon Fiber, Iron Tailings, Conductive Asphalt Concrete, Self-Sensing Response.

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OPTIMIZED REHABILITATION OF PAVEMENT IN WATERLOGGED CONDITIONS USING CEMENT, MARBLE DUST AND FLY ASH.

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Abstract- This research addresses the stabilization of these weak and expansive subgrade soils thereby collected at both sides in Haripur District; such as Hattar Road, Kot Najibullah-KN1 and road near Sarai Saleh. Many of these areas typically have poor drainage and/or unstable subgrade conditions which has led to frequent pavement failures and shorter road service life. This study was conducted to enhance Soil Stabilization and Durability characteristics of soil using Cement, Fly Ash, and Marble Dust as sole binder material and in binary and ternary combinations. Laboratory tests were performed in accordance with ASTM standard test methods for grain size distribution, Atterberg limits (liquid limit, plastic limit), Modified Proctor compaction, California Bearing Ratio (CBR), expansion index and swelling potential. The soil was mixed with varying proportions of stabilizing additives (5–30 %), to evaluate the optimum mixture. Soils have high plasticity, which has a low-bearing capacity and CBR values in the range of 3.2%-3.8% (unserviceable). As expected, the untreated soils require stabilization. Of all the mixtures, the one consisting of 20% Cement and 10% Marble Dust obtained the highest CBR value, which was about 21%, and therefore it is appropriate for use in heavy-duty pavement applications. The ternary mixture made up of 20% Cement, 5% Fly Ash, and 5% Marble Dust had only slightly less strength but did improve workability, reduced the amount of cement used, and increased sustainability. On the other hand, going beyond a total additive content of 25–30% led to excessive stiffness and a decline in performance. The study as a whole show that appropriate proportioning of admixture-based stabilisation greatly enhances the strength, durability, and cost-effectiveness of the subgrade, offering practical advice for the construction of pavements in areas with waterlogged and expansive soils.

Keywords- Subgrade Stabilization, Waterlogged Conditions, Pavement Rehabilitation, Cement, Marble Dust, Fly Ash, Haripur.

MICROSTRUCTURAL ANALYSIS OF ASPHALT PAVEMENT MIXTURES REJUVENATED USING WASTE OILS.

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Abstract- The encouraging demand for green road construction and the limited availability of natural resources enforces the need for modern asphalt recycling solutions. The present research investigates the viability of Waste Cooking Oil (WCO), Waste Engine Oil (WEO), and Recycled Bitumen as rejuvenators in asphalt mixtures with 50% Reclaimed Asphalt Pavement (RAP) and Margalla aggregates, locally available from Haripur, Pakistan. Rejuvenated mix was compared with a control mix of 60/70 grade bitumen against a series of binder and performance tests. Binder tests showed improved flexibility, elasticity, and workability in the rejuvenated mix with an increase in penetration from 53 to 67 dmm, ductility from 75 to 92 cm, and viscosity decrease at 135°C. Microstructural analysis using FTIR, XRD, XRF, and HPLC confirmed the recovery of critical functional groups and homogenous mixing of rejuvenators. Performance tests showed an increase in rutting resistance by 12% and an increase in fatigue life by 18%, along with enhanced resistance to moisture. The findings indicate the viability of WCO and WEO in the manufacturing of green, long-lasting asphalt, reducing the utilization of virgin material. The research advocates the formulation of cost-effective and environmentally friendly pavement solutions for Pakistan's road infrastructure

Keywords- Asphalt pavement; Microstructural Analysis; Waste cooking oil; Waste cooking oil; Rejuvenated Asphalt Mixtures; Reclaimed asphalt pavement.

OMAN-PAKISTAN OIL PIPELINE: POSSIBLE SOLUTION FOR ASIAN ENERGY CRISIS AIMED MIDDLE EAST WAR

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Abstract- The 2026 Iran war is a part of a decade long Middle east crisis comprises regional and local conflicts. However, the resent event has triggered the global energy crisis due to the blocking of the Hurmuz strait and subsequent suspension of oil and gas transport. This study proposes an offshore oil pipeline connecting Oman and Pakistan. The pipeline will traverse the Gulf of Oman via the shortest possible route and will bypass the strait of Hurmuz. The proposed pipeline is expected to deliver about 100,000 m^3 of crude oil daily and can have a diameter of 100 cm. The project is expected to supply the energy requirements of Pakistan China and other regional countries without relying on the shipping routes which are vulnerable under the war scenarios. The capital required for the construction of offshore oil pipelines and environmental challenges regarding marine and terrestrial ecosystems are the key challenges of the proposed project.

Keywords- Offshore Pipeline, Middle East War, Energy Crisis, Oil Transport, Hurmuz Strait.

RECYCLED CONSTRUCTION AND DEMOLITION WASTE AGGREGATES IN HOT MIX ASPHALT: A STATE OF THE ART REVIEW

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Abstract- Construction and demolition (C&D) waste has become one of the largest waste streams worldwide due to rapid urbanization and infrastructure development. Disposal of this waste in landfills creates environmental and economic challenges while increasing the demand for natural construction materials. Recycling C&D waste as aggregates in Hot Mix Asphalt (HMA) has emerged as an effective solution for sustainable pavement construction. This review summarizes recent studies on the use of Recycled Concrete Aggregate (RCA) and Reclaimed Asphalt Pavement (RAP) in asphalt mixtures. The paper discusses material properties, laboratory performance, environmental benefits, and current challenges. Previous studies have indicated that recycled aggregates can provide satisfactory Marshall Stability, moisture resistance, and rutting performance when replacement levels are properly controlled. Although recycled aggregates require slightly higher asphalt binder due to increased water absorption, replacement levels up to 50% generally produce satisfactory engineering performance. The review concludes that recycled aggregates offer an environmentally friendly and economically viable alternative for sustainable pavement engineering while reducing landfill disposal and conserving natural resources.

Keywords- Construction and Demolition Waste, Recycled Concrete Aggregate, Reclaimed Asphalt Pavement, Hot Mix Asphalt, Sustainable Pavements.

EFFECT OF ORGANOCLAY ON THE TRIBOLOGICAL BEHAVIOR OF HOT MIX ASPHALT

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Abstract- Rutting (permanent deformation) is a major issue to flexible pavements in tropical and subtropical areas due to the high temperature and heavy traffic loads. Economical, but highly durable asphalt binders are needed for the infrastructure in such areas. The modification with Organo-clay is one of the potential solutions to improve the structural stiffness. The mechanical properties of the modified binders are investigated by different researchers, but the tribological lubricating properties during the critical stage of field compaction are still under-explored. First of all, physical and thermal properties of bitumen modified with organo-clay is tested and analyzed in addition to the advanced interfacial analysis. The tribological behavior of modified binder is studied against simulated field compaction cooling (140°C to 60°C) in a pin-on-disc tribometer in this study. This set-up measures friction of aggregate and binder under different dosages of modifier. The temperature-dependent coefficient of friction, the wear volume and cumulative energy dissipation of the mastic is monitored. The conventional results indicate progressive improvement in high-temperature stiffness and thermal safety (up to 328°C) whereas tribological results confirm the optimisation of 4% organo-clay dosage in terms of boundary and mixed lubrication. The binder film can significantly cut down the wear volume of the aggregates by 69%, the coefficient of friction by 67% and the total compaction energy demand by 58% at this concentration, while the effect diminishes with higher concentrations because of the creation of agglomerates of nanoparticles. The results of this study show that 4% organo-clay modification is effective in reducing compaction effort in the field while maximizing pavement workability, final density and in-service durability.

Keywords- Hot Mix Asphalt, Organo-Clay, Tribology, Compaction Energy, Coefficient of Friction.

ASSESSING THE IMPACT OF CHANNEL BED SEDIMENTATION ON FLOOD INUNDATION USING HEC-RAS 1D: A CASE STUDY OF JHELUM RIVER

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Abstract- Sedimentation in river channels progressively reduces the conveyance capacity of waterways, increasing the flood water surface and increasing the lateral spread of inundation. This paper investigates the hydraulic significances of channel bed sedimentation along a reach of the Jhelum River, Punjab, Pakistan, using one dimensional steady flow modelling in HEC-RAS. Two scenarios are developed and compared: A Baseline Model representing the (theoretical) existing sediment accumulated river bed as extracted from ALOS PALSAR 12.5 m Digital Elevation Model (DEM), and a Modified Bed Model in which the irregular sedimentation induced terrain is removed to simulate the condition of a maintained, hydraulically efficient channel. The principal hydraulic outputs examined are water surface elevation, flood inundation depth, and cross sectional flow velocity across the study reach. Results demonstrate that the sediment baseline channel produces substantially higher water levels and broader inundation extents compared to the maintained channel scenario. Flow velocities exhibit an inverse pattern, with the modified bed showing overall higher channel velocities due to improved hydraulic radius and depth. This study represents comparative analysis approach of theoretical model.

Keywords- Sedimentation; Flood inundation; HEC-RAS 1D; Jhelum River; River bed maintenance; Water depth; Flow velocity; DEM; Channel conveyance.

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EXPERIMENTAL INVESTIGATION OF COEFFICIENT OF DISCHARGE OF ARCED PIANO KEY WEIR WITH VARYING CREST SHAPES

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Abstract- Weirs are widely used hydraulic structures for flow regulation, discharge measurement, and water level control in open channels. Among the various weir configurations, the Piano key weir has gained considerable attention because it provides a high discharge capacity within a relatively small footprint, making it particularly suitable for rehabilitation of existing spillways and sites with limited available width. PKW involves a lot of geometric parameters which have considerable impact on hydraulic efficiency and these geometric parameters have not thoroughly been investigated in literature. In this experimental research work two cases of arced PKW crest shapes including rectangular and half-rounded were considered and their impact on coefficient of discharge have been investigated. The results showed that variation of crest shapes of PKW has a considerable impact on its discharge capacity. It was observed that the coefficient of discharge of half-rounded crest shapes (C_d= 2.04 at H/P= 0.063 and C_d= 0.82 at H/P=0.16) was found to be more than rectangular crest shapes (C_d= 1.07 at H/P= 0.097 and C_d= 0.56 at H/P=0.2). Moreover, the hydraulic efficiency of arced PKW was found to be highest at lowest H/P ratio. Furthermore, at any value of u/s Fr the value of C_d was found to be more for the case of half-rounded crest shapes than rectangular.

Keywords- Arced Piano key weir, Coefficient of discharge, Crest shapes, Experimental study

EFFECT OF OVERHANG LENGTH ON COEFFICIENT OF DISCHARGE OF TYPE-B PIANO KEY WEIR

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Abstract- Piano key weirs (PKWs) are a highly evolved overflow-type structure that can be used when traditional linear weir designs are unable to accommodate sufficient discharge in a channel. PKWs are applicable to a wide range of hydraulic structures and are not confined to narrow channel reaches. The hydraulic performance of PKW is greatly affected by geometric parameters, such as the overhang length at the inlet. This study aims to conduct an experimental investigation on the influence of overhang length on the discharge coefficient of Type-B PKW. The laboratory experiments were carried out in a 10m long rectangular flume with six different Bi/Bb ratios of 0.33, 0.67, 1.00, 1.33, 1.67, and 2.00. A total of 42 experimental runs were conducted in seven different discharge conditions varying from 0.01482 to 0.02208 m^3/s. The characteristic measurement of hydraulic performance was the discharge coefficient (Cd). The results showed that among all the configurations, the Cd decreased with the increase in relative head ratio h/P, and Cd increased with increasing inlet overhang ratios (Bi/Bb), causing the discharge efficiency to improve. It was noted that the highest Cd was found at the Bi/Bb = 2.00, while the lowest Cd was observed at the Bi/Bb = 0.33. Results have revealed that the hydraulic efficiency and flow capacity of the Type-B PKWs can be significantly enhanced by increasing the length of the overhang towards the inlet.

Keywords- Discharge Coefficient, Hydraulic Performance, Inlet Overhang Length, Piano Key Weir.

QUANTITATIVE ASSESSMENT OF URBAN HEAT ISLAND HOTSPOTS IN KARACHI USING A MULTI-CRITERIA GRADING MATRIX

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Abstract- Rapid urbanization in Karachi has significantly altered the urban fabric, leading to increased impervious surfaces, reduced vegetation, and intensified Urban Heat Island (UHI) effects. Accurate identification of UHI hotspots is essential for climate-resilient urban planning; however, conventional single-parameter methods using Land Surface Temperature fail to capture the multi-dimensional nature of urban heat dynamics. This study proposes a multi-factor grading matrix to systematically assess and map UHI intensity across Karachi. The framework integrates key environmental and urban parameters, including land surface temperature (LST), mean air temperature, building density, green cover, albedo, humidity, wind speed, and Air Quality Index (AQI). Each parameter is assigned threshold-based grades and equal weightage to compute a composite UHI score for selected urban areas. Data were collected using a combination of remote sensing (Sentinel-2 imagery), Geographic Information Systems (GIS), field measurements, and secondary climatic datasets. The grading matrix was applied to twelve towns, and spatial variability in UHI intensity was analyzed. The results reveal significant spatial heterogeneity, with Liaquatabad Town, Gulberg Town, Gulshan-e-Iqbal Town, and Gulistan-e-Jauhar Town identified as very high UHI zones, primarily due to extreme building density, minimal green cover, low albedo, and adverse microclimatic conditions. The findings highlight the strong influence of urban morphology and environmental parameters on heat accumulation. This study contributes to the development of evidence-based mitigation strategies and supports sustainable urban planning aimed at enhancing climate resilience in rapidly urbanizing cities.

Keywords- Urban Heat Island (UHI), Thermal Vulnerability Mapping, Multi-Criteria Grading Matrix

LIFE CYCLE ASSESSMENT OF SUSTAINABLE BIOPLASTIC PRODUCTION FROM FOOD AND AGRICULTURAL WASTE STREAMS IN PAKISTAN

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Abstract- Plastic waste has become one of the biggest environmental problems in the modern world. Traditional plastics are made from petroleum-based materials and cause serious environmental problems due to their non-biodegradable nature, persistence and toxicity. To overcome this problem, this study aims to investigate the environmental performance of a bioplastic produced from food and agricultural waste materials available in Pakistan. The bioplastic has been prepared using sugarcane bagasse, corn cob waste, orange peel fractions, starch, glycerin, citric acid, and mustard oil. These waste materials are easily available in Pakistan and can help reduce agricultural waste pollution. To evaluate the environmental impacts of the bioplastic production process, a "Cradle-to-Gate" Life Cycle Assessment (LCA) has been conducted using OpenLCA 2.6.1 software and the Ecoinvent v3.10 database. The Environmental Footprint (EF v3.1) method has been used to calculate environmental impacts. The Life Cycle Impact Assessment (LCIA) results showed that producing 1 kg of finished bioplastic generated 18.36 kg CO_2-equivalent greenhouse gas emissions. The results also showed that the largest contribution to environmental impacts came from electricity consumption during laboratory processing. About 91.05% of the total climate change and acidification impacts were caused by electricity used in heating, stirring, and drying operations. The outcomes are helpful for future researchers and policymakers striving to promote environmental sustainability.

Keywords- Bioplastics, Carbon Footprint, Circular Economy, Life Cycle Assessment.

INVESTIGATING THE IMPACT OF URBANIZATION ON LAND USE AND LAND COVER IN PAKISTAN FOR SUSTAINABLE FUTURE: A CASE STUDY OF LAHORE CITY

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Abstract- Urban Heat Islands (UHIs) are causing environmental problems to worsen, and urbanization is changing land surfaces at a rapid pace. This study examines how land surface temperature (LST) and changes in land use and land cover (LULC) brought about by urbanization interact in Lahore, Pakistan. Landsat images from 2000, 2010, and 2020 was analyzed using remote sensing and GIS tools to categorize LULC and evaluate temporal trends. Increased urban expansion is indicated by the data, which show a significant increase in built-up area and a decrease in vegetation cover. The quantity of area covered by buildings grew from 215 km² to 515.91 km² between 2000 and 2020. Over 20 years, the rate of urbanization expansion reached 48.39%. Environmental stress and elevated surface temperatures are the outcomes of these changes.

Keywords- Urbanization, LULC, GIS, Remote Sensing, Urban Heat Island, Lahore

PERFORMANCE ASSESSMENT OF FERRIC OXIDE COATED SOLAR-POWERED SELF-CLEANSING ACTIVE LIVING WALL FOR INDOOR AIR QUALITY MANAGEMENT

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Abstract- Uncontrolled population growth and rapid urbanization have made air pollution a global issue. The concentration of indoor air pollutants is 2 to 5 times higher than typical outdoor concentrations. For indoor pollution control, electrostatic precipitators, ionizers and UV photolysis are used, however, these technologies are expensive and provide less technical efficiency. Additionally, living and green walls have also been used previously to fulfill the purpose. Recently, the concept of active living wall (ALW) has been introduced which is an efficient and cost-effective method to combat indoor air pollution. In its assembly, solar panels, photocatalytic spray, filter media and humidifier are used to effectively combat indoor air pollution. In this study, the performance of ALW has been analyzed during a 30-day monitoring period including 15 days without ALW (baseline) and 15 days with ALW installation. A total of 180 hourly readings has been obtained for carbon dioxide (CO_2), particulate matter ($PM_{1.0}$, $PM_{2.5}$ and PM_{10}), formaldehyde (HCHO), total volatile organic compounds (TVOC), temperature and relative humidity. The ALW exhibited quite high pollutant decreasing efficiencies of 58.27% for $PM_{1.0}$, 51.68% for $PM_{2.5}$, 42.42% for PM_{10}, 54.54% for HCHO, 39.70% for TVOC and 51.78% for CO_2 (i.e., p-value < 0.05). The indoor temperature rose to 3.2 ºC and relative humidity increased to 8.1%, which is attributed to seasonal variation and effects of plant transpiration. The outcomes support that ALW is a hybrid biofiltration assembly that can greatly improve the indoor air quality. Moreover, its integration in cafeterias, classrooms, offices and other high-occupancy indoor environments provides a sustainable and energy-efficient alternative to conventional air purification technologies.

Keywords- Active living wall, Air pollution, Environment, Indoor air quality, Nature-based solutions, Phytoremediation

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COMPARATIVE LIFE CYCLE ASSESSMENT OF CONVENTIONAL AND ZERO DISCHARGE OF HAZARDOUS CHEMICALS (ZDHC)-COMPLIANT TEXTILE WASTEWATER TREATMENT SYSTEMS

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Abstract- The textile industry is a major contributor to industrial wastewater generation, releasing significant quantities of dyes, salts organic pollutants and hazardous chemicals into aquatic environments. The zero discharge of hazardous chemicals (ZDHC) framework has emerged as a sustainable approach aimed at minimizing hazardous chemical releases and improving wastewater management practices within the textile sector. This study exhibits a comparative life cycle assessment (LCA) of conventional wastewater treatment and ZDHC-compliant wastewater treatment systems for textile effluent management. The assessment was conducted using OpenLCA software with a gate-to-gate system boundary and $1m^3$ of textile wastewater treated as a functional unit. Life cycle inventory (LCI) data was obtained from published literature and modelled using the ELCD database. Environmental impacts were evaluated using ReCiPe 2016 midpoint (H) and CML-IA assessment methods across multiple impact categories including global warming potential, acidification, eutrophication, human toxicity, freshwater aquatic ecotoxicity, marine aquatic ecotoxicity, terrestrial ecotoxicity, photochemical oxidation and ozone layer depletion. The results indicate that the ZDHC-compliant wastewater treatment system exhibits dominant environmental performance in most impact categories, achieving notable reductions in eutrophication potential, toxicity-related impacts and greenhouse gas emissions. The findings demonstrate ZDHC-compliant wastewater treatment technologies to enhance environmental sustainability and support cleaner production and responsible chemical management practices.

Keywords- Conventional activated sludge (CAS), Life cycle assessment (LCA), Textile wastewater treatment, Zero discharge of hazardous chemicals (ZDHC).

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WASTEWATER TO GREEN WATERSCAPE: A NATURE-BASED ENGINEERING FRAMEWORK FOR SUSTAINABLE URBAN WATER MANAGEMENT

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Abstract- Rapid urbanization, industrialization, and freshwater scarcity have increased the demand for sustainable wastewater management systems. However, conventional wastewater treatment plants are energy-intensive, expensive to operate, generate large amounts of sludge, and provide limited opportunities for water reuse and groundwater recharge. This study proposes an integrated nature-based wastewater management framework for the I-9 Industrial Area, Islamabad, to improve treatment efficiency while enhancing environmental sustainability and strategic urban development. The novelty of the proposed framework lies in integrating gravity-driven constructed wetlands, phytoremediation, strategic plantation, and groundwater recharge within a single engineering system using complementary wetland macrophytes and native tree species. The methodology included a comprehensive review of recent studies from high-impact journals, followed by site selection and spatial analysis using the CDA Masterplan (2026–2050), Google Earth Pro, Open Street Map, digital elevation models, and geospatial datasets to assess wastewater infrastructure, drainage patterns, land suitability, and implementation feasibility. Based on the analysis, a conceptual treatment framework was developed without physical implementation. The proposed framework is expected to achieve high treatment efficiency, reduce energy use by 40–70%, lower operation and maintenance costs by 30–60%, and recover over 80% of treated wastewater, offering a practical and low-carbon approach to sustainable urban wastewater management.

Keywords- Constructed wetlands, Groundwater recharge, Nature-based wastewater treatment, Strategic plantation