ICM 2023

THEME : RESILIENCE AND SUSTAINABILITY

BOOK OF ABSTRACTS

SECOND INTERNATIONAL CONFERENCE ON ADVANCES IN CIVIL INFRASTRUCTURE AND CONSTRUCTION MATERIALS

26-28 JULY 2023

DEPARTMENT OF CIVIL ENGINEERING, MIST

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CICM-2023
26-28 July 2023, Dhaka

Second International Conference

on

Advances in Civil Infrastructure and Construction Materials

Book of Abstracts

Organized by
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Military Institute of Science and Technology
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Minister
Ministry of Local Government,
Rural Development &
Cooperatives
Government of the People's
Republic of Bangladesh

Message

I am pleased to warmly welcome all attendees of the Second International Conference on Advances in Civil Infrastructure and Construction Materials (CICM). This momentous event, scheduled at the Military Institute of Science and Technology (MIST), Mirpur Cantonment, Dhaka, from 26th to 28th July 2023, marks a significant milestone for the academic domain of Bangladesh.

In 2021, Bangladesh fulfilled all three criteria to graduate from the LDC category to a developing country. The government has launched its second long-term plan (Perspective Plan 2021-2041) where infrastructure development is one of the three main focuses. It aims to develop infrastructure sustainably that will help achieve the Sustainable Development Goals (SDG). It also aims to improve connectivity and accessibility by developing transport infrastructure such as roads, highways, railways, waterways, and airports. The present government of honourable Prime Minister Sheikh Hasina has also fostered the vision of the Developed Country by 2041 and Delta Plan 2100. Civil engineers are crucial in achieving these goals for the nation and people. The evidence of their significant contributions is apparent through the development of mega-structures like the Padma Bridge, Rooppur Nuclear Power Plant, Payra Port, and Dhaka Metro Rail Project, and many more. Military Institute of Science and Technology (MIST) is now one of the leading engineering institutes in Bangladesh. It is devoted to imparting high-quality education and lifelong learning to mass people and military students. MIST's motto, "Technology for Advancement" is achieved by developing world-standard classrooms, laboratory facilities and other amenities for the students.

This conference would be an invaluable platform for sharing knowledge, exchanging ideas, and fostering collaboration among civil engineers. I want to thank the Honorable Prime Minister, Commandant of MIST, and Department of Civil Engineering, MIST, for hosting this significant event.

Md. Tazul Islam, MP

Adviser and Professor Emeritus
C3ER, BRAC University
&
Chair – CICM 2023

Message

I am happy to welcome all the participants to the 2nd International Conference on Advances in Civil Infrastructure and Construction Materials (CICM), which is being held at Mirpur Cantonment, Dhaka from 26th to 28th July 2023. I whole heartedly appreciate the initiative taken by the Department of Civil Engineering, Military Institute of Science and Technology in organizing the conference, which is being attended by a large number of eminent speakers and participants from different countries across the globe.

Development of civil infrastructure is a prerequisite for the socio-economic development of a country. Consequently, the demand for construction of modern civil infrastructure is ever growing, particularly for a developing country like Bangladesh which is undertaking many mega projects to transform to a developed country by 2041 to fulfill the father of the nation's dream of a "Golden Bangladesh". Civil Engineers have a major role to play in the development of the country through innovation and cutting-edge technologies. Advances in civil engineering technology and improvement in cost effective construction materials can immensely benefit the country both socially and economically.

Through this conference, an attempt has been made to bring researchers, academicians, practicing engineers, consulting engineers, owners, and construction managers, together on a single platform, to discuss various issues on advances in civil engineering infrastructure and construction materials. I am sure that participants of this conference will be immensely benefitted from the presentation by renowned keynote and distinguished speakers and interactions with them.

I am confident that CICM 2023 will be a successful forum for professionals from all over the world, enabling them to share their technical knowledge, views, and experiences.

I wish CICM 2023 a grand success.

Dr. Ainun Nishat
Adviser and Professor Emeritus
Centre for Climate Change and Environment Research (C3ER)
BRAC University, Bangladesh

A/Commandant, MIST
Mirpur Cantonment
&
Chief Patron – CICM 2023

Message

I am delighted to express my heartfelt gratitude to the Civil Engineering Department of the Military Institute of Science and Technology (MIST) for organizing the International Conference on Advances in Civil Infrastructure and Construction Materials (CICM) for the 2nd time at Mirpur Cantonment, Dhaka on 26-28 July 2023. The Department of Civil Engineering, the pioneer department of MIST, stands out as a beacon of knowledge and creativity, guiding students to a future full of limitless possibilities since its inception in 1998.

Sustainable Development Goals (SDG) Number 9 incorporates resilient infrastructure, sustainable industrialization, and innovation. Bangladesh government has adopted Vision 2041 as a continuation of Digital Bangladesh Vision 2021, seeking to take the nation to the development path. Through its steadfast commitment to excellence, the Department of Civil Engineering is playing an important role in producing highly qualified civil engineers at the forefront of sustainable infrastructure development nationwide. Led by devoted faculty members, the department develops individuals with technical capabilities and the vision and drive to improve the world.

I am overwhelmed to be informed that great scholars worldwide will present their valuable contributions to this magnificent and prestigious conference. I am also delighted that many international universities and professional organizations actively support this event. I hope this conference will play an essential role in professional expression and information exchange in the best manner possible. I express my heartfelt gratitude to the speakers, participants, organizers, and volunteers.

I wish all the success of CICM-2023.

Brigadier General Md Wahidul Islam, SUP, ndc, psc

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SEISMIC RESILIENCE THROUGH A FRAME-SPINE SYSTEM WITH FORCE-LIMITING CONNECTIONS

Larry FAHNESTOCK

Department of Civil and Environmental Engineering, University of Illinois Urbana-Champaign

Abstract. Seismic resilience, or post-earthquake functionality, requires protection of a building and its contents and occupants, particularly for an essential facility, such as a hospital. Ongoing collaborative research by an international team is investigating a new system to provide enhanced seismic performance and continuity of building operation using practical structural components, including (1) flexible steel moment frames, (2) stiff steel elastic spines and (3) force-limiting connections (FLC) that connect the frames to the spines. This Frame-Spine-FLC System aims to economically control building response and prevent damaging levels of story drift and floor acceleration. The moment frames serve as the economical primary element of the system to resist a significant proportion of the lateral load, dissipate energy through controlled nonlinear response and provide persistent positive lateral stiffness. The spines distribute response evenly over the height of the building and prevent story mechanisms, and the FLC reduce higher-mode effects and provides supplemental energy dissipation. The Frame-Spine-FLC System development is focusing on new construction, but it also has the potential for use in seismic retrofit of deficient existing buildings. This presentation provides an overview of the ongoing research project, including a description of full-scale shake-table testing that was conducted for a building with the Frame-Spine-FLC System, which represents a hospital facility and includes realistic nonstructural components and medical equipment. The story drift control and floor acceleration reduction demonstrated through full-scale experiments illustrate the viability of the new system and provide a foundation for further development and application.

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RISK, RESILIENCE AND SUSTAINABILITY OF CIVIL INFRASTRUCTURE UNDER SINGLE AND MULTIPLE HAZARDS IN A LIFE-CYCLE OPTIMIZATION FRAMEWORK

Dan M. FRANGOPOL

Department of Civil and Environmental Engineering, ATLSS Center, Lehigh University, Bethlehem, PA 18015-4729, USA

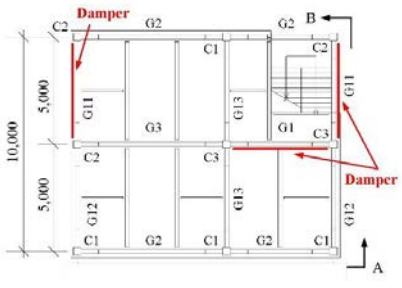
Abstract. Decisions regarding design, assessment and maintenance of civil infrastructure should be supported by an integrated risk-, resilience- and sustainability-based life-cycle multi-objective optimization framework by considering, among other factors, the likelihood of successful performance and the total expected cost accrued over their entire life. The primary objective of this keynote lecture is to present a life-cycle multi-objective optimization framework for risk-, resilience- and sustainability-informed decision making for civil infrastructure under lifetime hazards including corrosion, earthquake, and climate change. Several important performance indicators such as risk, resilience, and sustainability necessary to be implemented in the design, assessment and maintenance of civil infrastructure under single and multiple hazards are introduced. Bridges and bridge transportation networks are used to illustrate the application of the proposed life-cycle optimization framework.

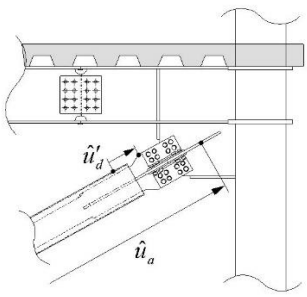
E-DEFENSE SHAKE-TABLE TESTS AND CORRELATIVE ANALYSES ON FULL-SCALE 5-STORY BUILDINGS WITH/WITHOUT DAMPERS

Kazuhiko KASAI

Tokyo Institute of Technology, Japan

Abstract. The E-Defense shaking table facility completed in 2005 is the largest earthquake simulator capable of subjecting full-scale structures to the strongest earthquakes recorded in the world. The writer was given an opportunity to play a leading role in three test projects on different types of steel buildings using the E-Defense (2006-2011). Many researchers from Japan and US participated in the projects to study: 1) collapse of a conventional 4-story structure; 2) performance of innovative 3-sytory rocking structures with dampers, and; 3) response-control effectiveness for the 5-story structures with 4 different dampers available in the market, respectively. This presentation focuses on the third project, which was the most extensive involving the largest group of researchers and largest amount of response data. The full-scale 5-story building in Fig. 1 was tested repeatedly, inserting and replacing each of 4 damper inserting., 12 steel dampers, 12 nonlinear viscous dampers, 12 oil dampers, and 12 viscoelastic dampers. The building without dampers were also tested after the above series. The objective was to validate response-control technologies that were increasingly adopted for major Japanese buildings without being attested by a major earthquake. As aimed at during design, the four types of dampers lead to similar and well-controlled peak responses of the buildings at the 100%-scaled JR Takatori station ground motion, one of the most severe motions recorded during the 1995 Kobe earthquake. As was also expected, under the smaller levels of Takatori ground motions, different dampers showed different control effects. The project demonstrated significant merit of value-added design using dampers. Extensive data were extremely valuable to the professional and academic communities, validating design, analysis, and evaluation methods. The number of sensors of about 1,400 reached practical limit and schedule of test was considerably pressing for the amount of data handled. The future challenging issue is to obtain much more data, significantly enhancing the data acquisition scheme, maximizing outcome of the realistic, rare, and expensive tests.





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CHRISTCHURCH POST-EARTHQUAKE RECOVERY

Gregory MACRAE

University of Canterbury, Christchurch, New Zealand

Abstract. The 2010-2011 Canterbury Earthquakes caused significant damage especially in the city of Christchurch. As a result, much of the infrastructure – vertical and horizontal - is being replaced. The presentation describes: the construction culture and laws before the earthquakes which shaped the recovery of the city; the damage itself; and changes/development to codes/guidelines. A description of types of structure constructed in the recovery is provided, and reasons for the selection of these structural systems is discussed. Societal aspects of the recovery are considered by examining the changes in organizations and people. Opinions are provided about what worked well and what could have been done better.

Keywords: Canterbury, Earthquake, Organizations, Recovery, Rebuild

ROLE OF ENGINEER'S CORPS OF BANGLADESH ARMY IN DIFFERENT MEGA INFRASTRUCTURE PROJECTS

Abu Syeed Md MASUD

Member, Panel of Experts, Padma Bridge Rail Link Project (PBRLP)

Abstract. The role of the Engineer's Corps of the Bangladesh Army in mega infrastructure projects has evolved significantly over the past four decades. Initially tasked with road and highway works in the Chittagong Hill Tracts, the Corps employed Engineering Construction Battalions from the Special Works Organization (SWO). With technological advancements, the SWO and ECB expanded, and now two brigades in Dhaka and Chittagong have increased numbers of ECB battalions. From 2006, the Corps took the lead in constructing flyovers, highways, and multidimensional projects. They became a trusted partner for ministries involved in mega structure development, collaborating with the Construction Supervision Consultancy Group (CSC) on projects such as the Padma Multipurpose Bridge and Padma Bridge Rail Link. The Corps, equipped with efficient officers and soldiers, embraces new technologies and innovations. Additionally, the Bangladesh Army has its own design team from the Military Engineering of Science and Technology (MIST). Notable projects include Chimbok-Thanchi Road, Bridge on Thanchi River, Hatirjheel Project, Jolshiri Abason Project, Multi Loop Flyover, Meghna and Gumti Bridges, Padma Bridge, and Padma Bridge Rail Link. The Corps' contributions have not only made the country proud but also elevated its civil engineering capacity.

TOWARDS BUILDING RESILIENCE THROUGH RECONNAISSANCE: ARTIFICIAL INTELLIGENCE APPROACHES FOR STRUCTURAL HEALTH MONITORING

Khalid M. MOSALAM

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Abstract. Natural hazards, that have been occurring in various forms, frequencies, and intensities are unavoidable. However, developing resilient built environment to these natural hazards is achievable. Among multiple ways of achieving community resilience, the Structural Extreme Events Reconnaissance (StEER) Network focuses on "Building Resilience through Reconnaissance." This approach uses data and observations after natural hazards to make a difference directly on the affected communities, to guide related research, and to inform policy, rather than the regular sequential cycle of these aspects. For data collection, a worldwide trend is the expansion of sensor installation on different elements of the built environment. The acquired big vibration and vision datasets from continuous monitoring and reconnaissance efforts are used to study the response of structures (e.g., buildings and bridges) and ultimately improve design code provisions and practices. The effective and accurate collection and use of data rely on advances in Structural Health Monitoring (SHM) to improve sustainability and resilience of cities and communities. This paper focuses on the activities of the StEER Network and two frameworks that use different modalities of data for achieving resilience using SHM and reconnaissance: (1) The establishment of the "Bridge Rapid Assessment Center for Extreme Events (BRACE2)" for real-time and near real time vibration-based SHM and operational decision making of instrumented bridges, and (2) The development of a hierarchical database, namely, "PEER Hub ImagNet" (ϕ-Net) for integrating multi-task deep learning mechanisms for vision-based SHM using images.

Keywords: Deep Learning, Natural hazards, Structural Health Monitoring.

AN INNOVATIVE STEEL BRACED FRAME SYSTEM FOR CONTROLLED SELF-CENTERING ELASTIC SEISMIC RESPONSE OF LOW-RISE STEEL BUILDING STRUCTURES

Robert TREMBLAY

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Abstract. The paper introduces an innovative steel braced frame system that designed and detailed and to exhibit an elastic self-centering hysteretic response to achieve damage-free seismic response for low-rise building structures. The system is implemented in the first storey of buildings such that all seismic induced deformations intentionally in the first-storey to achieve a seismic response to be offered by base isolation systems. The proposed system is described together with a design approach based on the single-mode analysis method that is now widely adopted for base isolation systems. The system is applied for two- to four-storey office buildings located in the high seismicity region of Vancouver, British Columbia, Canada, where the seismic hazard is contributed by shallow crutal, deep-in-slab, and interface subduction earthquakes. Nonlinear response history analysis is performed under site representative ground motion records to verify the seismic performance of the proposed system.

Keywords: Steel building structures, braced steel frames, self-centering response, energy dissipation, residual deformations.

COLD-FORMED STAINLESS STEEL DOUBLE SHEAR BOLTED CONNECTIONS IN FIRE

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Abstract. Currently, there is no design rule on cold-formed stainless steel bolted connections in fire condition. A total of 44 double shear bolted connection specimens with three different grades of stainless steel was tested in this study, where 28 specimens were tested by steady state test method and 16 specimens were tested by transient state test method. The three different grades of stainless steel are austenitic stainless steel EN 1.4301 (AISI 304) and EN 1.4571 (AISI 316Ti having small amount of titanium) as well as lean duplex stainless steel EN 1.4162 (AISI S32101). The connection specimens were assembled by two bolts that arranged perpendicular to the loading direction. Bearing failure and net section tension failure modes were observed in the connection tests. The test results were compared with the nominal strengths calculated from the design rules in the American Specification and European Codes for stainless steel structures at ambient temperature, where the nominal strengths of the connections calculated by using the material properties at elevated temperatures. It is shown that the codified strength predictions of the stainless-steel double shear bolted connections are generally conservative at elevated temperatures. The connection strengths decrease as the temperature increases in the similar manner for the steady state tests and the transient state tests. It is also found that the stainless-steel type EN 1.4571 generally has better resistance than the stainless steel types EN 1.4301 and EN 1.4162 for double shear bolted connections at elevated temperatures.

Keywords: Bolted connection, cold-formed stainless steel, failure modes, fire condition, steady state test, transient state test.

FUTURE INFRASTRUCTURES FOR THE PEOPLE BY THE PROFESSIONALS CRAFTED BY THE EDUCATORS

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Abstract. Bangladesh needs to keep its economy rising with sustainable growth. A healthy economy brings further opportunities for development. The power of development comes from the continuity achieved from sustainability. As the national growth crystallizes, increases in the scale of megaprojects will necessitate mega infrastructure. Success is rooted in education and professional development so that the best practices followed elsewhere can be better sieved into future development in Bangladesh when current professionals and the future generation of engineers run the show. Our education system foresees a paradigm shift in which future engineers trained for sustainable development goals not only acquire competencies for creative learning and thinking, complex problem-solving, interdisciplinary and international cooperation and ethical attitudes but also take an academic, technical, knowledge-focused path to a broader interdisciplinary approach to updated learning. The education system will see a shift from a teacher-centric focus to one more student-centered and problem-based.

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OPTIMIZATION OF MULTIPLE TUNED MASS DAMPER PARAMETERS USING EVOLUTIONARY OPERATION ALGORITHM CONSIDERING SOIL-STRUCTURE INTERACTION

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Abstract. Vibration control is important for structures subjected to dynamic loadings like earthquakes and wind. It is necessary to keep structural response within the acceptable limit and achieve the desired performance of structures. Among different structural control techniques, the Tuned Mass Damper (TMD) is an efficient option because of its simple principle and more straightforward implementation on existing buildings with comparatively modest rehabilitation. Appropriate selection of damper parameters is required for the structural system to perform efficiently against seismic loading. TMD parameters depend on period lengthening and increased damping due to soil-structure interaction. In the present study, a methodology has been developed to optimize Multiple Tuned Mass Damper (MTMD) parameters considering soil-structure interaction. A global optimization algorithm named Evolutionary Operation (EVOP) has been applied for optimization. A generalized equation of motion has been proposed for building frames with any number of stories associated with any number of Tuned Mass Damper (TMD) at different story levels subjected to seismic excitation. A computer program has been developed in C++ to perform a time-history analysis of the Structure-TMD system and has been linked with EVOP for optimizing TMD parameters. The optimization criterion is defined as the minimization of top displacement or inter-story drift. Soil-Pile interaction has been modeled using the Thin Layered Element Method (TLEM) for different soil-pile systems. Following the substructure method, soil-pile interaction has been incorporated into the superstructure, and optimization has been performed. The results show that excluding the SSI effects in the optimization overestimates the TMD's performance.

Keywords: Multiple Tuned Mass Damper (MTMD), Evolutionary Operations (EVOP), Soil-Structure Interaction (SSI), Thin Layered Element Method (TLEM)

CORROSION-INDUCED PERFORMANCE DEGRADATION OF BRIDGES - FROM MATERIAL TO THE INFRASTRUCTURE LEVEL

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Gradual deterioration of RC bridges due to chloride-induced corrosion is of concern for bridge durability, safety, and life-cycle performance under natural hazards. With the aim to quantify performance degradation of highway bridges along life-cycle, numerical analyses are performed to simulate chloride-induced corrosion and rust formation on steel rebars embedded in RC bridge piers having early-age surface cracks. For this purpose, a finite element analysis (FEA) framework integrating physiochemical and electrochemical processes of rebar corrosion with random generation of early-age cracks is developed to predict temporal progression of corrosion pit along the length and periphery of rebars in bridge piers. Outcome of the corrosion analysis is implemented in three-dimensional finite-element (FE) model of a representative bridge to estimate its capacity deterioration as time progresses. Nonlinear time-history analyses at various degraded states of the bridge are performed under a suitable suite of seismic ground motions to quantify time-dependent variations in bridge seismic performance. Obtained results are used to estimate life-cycle seismic resilience of the bridge, which is observed to reduce gradually with the progression of bridge deterioration.

Further, uncertainties arising from random natures of chloride diffusion parameters and material properties, temporal variations of atmospheric variables, and random patterns of early age cracks are studied to capture the variability in seismic performance and risk of bridge piers. Research outcome revealed that randomly distributed early-age cracks on pier surface accelerate the corrosion phenomenon resulting in lower seismic resilience of the bridge when compared to uniform pier corrosion (without surface cracks). In cases when spatial randomness of chloride concentration around bridge piers is considered in conjunction with early-age surface cracks, life-cycle seismic resilience of bridges becomes at its lowest level among all possible considered scenarios. Overall, the research outcome signifies the strong influences of early-age cracks in induction and propagation of pitting corrosion in RC bridge piers and elaborates the importance of considering randomness in corrosion process while predicting seismic performance of aging bridges in a life-cycle context.

Keywords: RC bridges, corrosion, life cycle resilience, FE modelling, uncertainty, seismic analysis

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EXPERIMENTAL VALIDATION OF LIFE-CYCLE-ORIENTED COMPUTATIONAL METHODS FOR STRUCTURAL ANALYSIS OF CONCRETE BRIDGES UNDER CORROSION

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Abstract. Life-cycle-oriented design, assessment, maintenance, and management of deteriorating structures and infrastructural facilities, such as bridges, should rely on structural analysis frameworks capable to account for time-variant structural performance. However, although life-cycle models are well established for some of the most detrimental damage processes, such as corrosion and fatigue, robust validation and accurate calibration are difficult tasks because of the limited availability of information about long-term performance of in-service structures. Gathering data from both inspection of existing structures and experimental tests is therefore of essence for a successful implementation in practice of life-cycle methods. This lecture is motivated by these needs and provides a contribution on computational modeling and experimental validation of nonlinear finite element analysis of reinforced concrete (RC) and prestressed concrete (PC) structures, with emphasis on life-cycle assessment of bridges under corrosion. Structural modeling is developed with different levels of complexity based on RC/PC beam finite elements accounting for the nonlinear stress-strain constitutive laws of the materials, i.e. concrete, reinforcing steel, and prestressing steel, and bi-dimensional finite elements for plane stress analysis formulated in accordance with the Modified Compression Field Theory. The proposed models are validated on the results of experimental tests on corroded RC beams available in literature, as well as on the outcomes of an ongoing extensive experimental campaign within the BRIDGE|50 research project aimed at investigating the residual structural performance of a decommissioned 50-year-old PC bridge.

INVESTIGATION OF PRESTRESSED CONCRETE BRIDGE GIRDERS UNDER OVERHEIGHT VEHICLE COLLISIONS

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Abstract. Prestressed Concrete Bridge Girders (PCBG) are susceptible to damage when exposed to over height vehicle collisions. This paper presents high-fidelity finite element models developed using LS-DYNA software. Thirteen models were validated against experimental data from the literature. The validated models were then implemented to perform a parametric study investigating the key factors affecting the dynamic response of PCBG under vehicle collisions, including vehicle speed and mass, girder span, and girder type. The response of each girder was quantified in terms of impact force time histories. The study revealed that relying solely on metrics such as peak impact force, kinetic energy, momentum, and impact speed is insufficient for accurate girder dynamic response representation. While the collision time is a critical factor that needs to be incorporated. Thus, the most critical factor can represent uniquely the dynamic response of prestressed girders is impact impulse. The results of this study can assist in the quantification of the dynamic demand and the development of design guidelines that will enhance the safety and resilience of prestressed bridge structures.

Keywords: Prestressed concrete, Bridge girder, Finite element, LS-DYNA, Vehicle collision, Resilience, Impact

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DESIGNING RESILIENT STRUCTURES AND COMPONENTS UNDER EXTREME LOADING CONDITIONS

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Abstract. Enhancing the resilience of structures and components under extreme loading conditions remains a significant challenge. This presentation will demonstrate several seismic resilience enhancement techniques for steel building moment connections. The first enhancement technique involves reducing the strength of steel over specified regions of the beam flanges by exposing the regions to high temperatures followed by slow cooling. This technique promotes the development of the beam plastic hinge away from the welded joint. The second technique involves relocating the bolts of an 8-bolt extended end plate connection to distribute bolt forces uniformly, thereby avoiding bolt and end plate failures. The third technique involves a new shear tab design and bolt arrangement of welded unreinforced flange bolted-web connections to more effectively transfer stress from the beam web to the column flange. The fourth seismic resilience enhancement technique involves stiffening the beam web within the plastic hinge region to delay the onset of local web and flange buckling resulting in the delay of strength degradation. Finally, ongoing research on enhancing the resilience of compact heat exchangers for next-generation very high-temperature reactors will be presented. The presentation will demonstrate how systematic experimental studies and rigorous simulation modeling facilitate the design of resilient structures and components.

Keywords: seismic resilience, welded steel connections, heat-treated beam sections, extended end plate connection, beam web stiffening, compact heat exchanger, constitutive modeling.

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LARGE-DEFORMATION FINITE ELEMENT MODELLING OF A LANDSLIDE IN LACUSTRINE/MARINE CLAY DEPOSITS

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Abstract. Large deformation and strain localization are two major issues in many geotechnical problems. However, in typical engineering practice, large-deformation analyses are not performed for these problems; instead, idealized or empirical approaches are often used. For example, a large-scale landslide generally occurs by progressive formation of failure planes where extremely large shear strains develop, and the failed soil blocks might displace several hundred meters. The commonly used limit equilibrium (LE) methods cannot explain this process. Physical modelling of such landslides, even in a centrifuge, cannot be done properly because the failure process is affected by debris flow, which cannot be modelled within the limited space. In this paper, a large deformation finite element (FE) modelling technique in the Eulerian framework is discussed. FE analyses are performed to simulate a landslide that occurred in lacustrine/marine clay deposits in Northern Peninsula, Newfoundland and Labrador, Canada. Although the complex processes of triggering the landslide and soil behaviour could not be modelled accurately, the simulations using the undrained behaviour of soil provide failure patterns similar to that observed in the field.

Keywords: Large deformation, Finite element modelling, Progressive landslide, Lacustrine/Marine Clay.

NEW SEISMIC DESIGN PROVISIONS IN BNBC-2020: A QUICK APPRAISAL

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Abstract. The updated Bangladesh national building code (legally enacted as BNBC-2020) contains new seismic design provisions including a new seismic zoning map dividing the country into four seismic zones with seismic zone coefficients varying from 0.12 to 0.36. This paper briefly explains the salient features and significance of these provisions which were finalized way back in 2010. Since then there have been new developments and new research in the field of seismological research and earthquake engineering. A general appraisal is done on some of the important code provisions related to consideration of seismic loads through brief comparison with other building codes and research publications both new and old. Several seismic hazard assessment studies, both probabilistic and deterministic, have been conducted for Bangladesh adopting different procedures. Particular reference will also be made to a recent publication indicating the possibility of a mega earthquake (magnitude 8.2 to 9.0) deep inside Bangladesh. Bangladesh is located at a complex seismo-tectonic regime close to the plate boundaries of Indian plate and Eurasian plate in the north as well as plate boundaries of Indian plate and Burmese sub-plate in the east. It is emphasized that it is indeed a great challenge to conduct seismic hazard assessment of Bangladesh and several years of coordinated seismological research work needs to be carried out for a realistic assessment.

Keywords: Building code, seismic zoning map, seismic zone coefficients, seismic design provisions, seismic hazard assessment.

SUPERELASTIC SMAS FOR IMPROVED SEISMIC PERFORMANCE OF CONCRETE STRUCTURES

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Abstract. Over the past two decades, research on retrofit methodologies and new construction that incorporate Shape Memory Alloys (SMAs) as the main structural material has intensified. This was in direct response to several major earthquakes over this time, which highlighted that while structures may not collapse and satisfy the life-safety performance criteria prescribed in building codes, the damage is often to the extent that demolition is the only viable alternative. Based on these observations, research on structural resilience with self-centering as a focal point began to emerge as an important criterion for the performance of structures. This provided the foundation to explore other materials not commonly considered in structural engineering, with SMAs coming to the forefront as a promising alternative. This paper will provide a review of both experimental and numerical research that has been conducted over the past 15 years on the implementation of Superelastic (SE) SMAs in retrofit applications or as part of structural components in new concrete construction. Specifically, retrofitting applications have included: diagonal, tension only SMA braces to retrofit deficient squat shear walls; and a proposed SMA buckling restrained brace to retrofit deficient concrete frame structures or to strengthen new concrete frame buildings. For new construction, the focus has been on slender concrete shear walls given their popularity in North America as the main seismic force resisting system. One of the criteria in the construction of these walls has been to limit the usage of SE-SMA internally within the boundary zone of the plastic hinge region, while the remainder of the reinforcement detailing consisted of traditional deformed steel reinforcement. Complementary to this work has been the performance of the walls after repairing, where the repair incorporated either Self-Consolidating Concrete (SCC) or Engineered Cementitious Composite (ECC) as a replacement for the heavily damaged concrete in the plastic hinge region. While the SCC provides an efficient choice to repair local areas in a structural component, ECC is viewed as an emerging option to complement sections that are reinforced with SMA bars. ECC is characterized by higher tensile strength and significantly greater tensile ductility relative to normal concrete, resulting in improved damage control which complements the self-centering phenomenon of SE-SMA. This paper will also include preliminary numerical modelling that has been conducted on the slender shear walls and concrete frame buildings to illustrate the impact of SMAs on the response at full-scale.

CYCLIC STRESS-STRAIN MODEL FOR CIRCULAR CONCRETE-FILLED STEEL TUBULAR COLUMNS

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Abstract. Concrete-filled steel tubular (CFT) columns are becoming more widely used because of their superior strength and ductility. Another benefit of CFT is that it eliminates the need for formwork during construction. The accurate behavior of concrete under compressive cyclic loading is particularly important for the seismic-resistant design of structures, as the tensile strength of concrete is often neglected in the design of steel-concrete composite structures. In the present study, a confinement model for cyclic compression has been proposed which can predict the behavior of concrete confined in a circular CFT column. The proposed model is inspired by the previous models of cyclic axial compression developed for concrete confined either with steel reinforcement ties or with fiber-reinforced polymer (FRP). The main components of the cyclic model, i.e., the envelope curve and the loading-unloading curves, are suitably modified to accurately represent the behavior of concrete in a CFT column. In addition to the concrete strength, steel tube strength, and tube diameter-to-thickness ratio, the proposed model also considers the effect of the length-to-depth ratio of the CFT column. Further, the proposed model has been validated with the experimental results and can reasonably predict the peak as well as post-peak behavior.

Keywords: Buckling, Confinement Model, Cyclic Compression, Slenderness Ratio, Steel-Concrete Composite.

A NOVEL METHOD FOR DESIGN OF HIGH PERFORMANCE CONCRETE WITH MULTIPLE PERFORMANCE REQUIREMENTS

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Abstract. Proper design of HPC is very important for specific project and applications. In this study, the seven-batch factorial design was used to correlate the Portland cement–slag– fly ash ternary compositions with different properties of concrete mixtures. In Changsha subway project, it is requested that C30 concrete should satisfy compressive strength larger than 38MPa, cracking time less than 28d, expansion from alkali-aggregate reaction less than 0.1%, chloride migration coefficient less than 5.0× 10-12m2/s, electrical resistance larger than 25000 ohm, and carbonation depth less than 6.5mm. When the factorial design method was applied, an area satisfied all the above requirements could be acquired.

Keywords: High performance concrete; performance-based design; ternary factorial design; Changsha subway; durability

TOWARDS EARTHQUAKE RESILIENCE: USING SUPERELASTIC SMA FOR HIGH-PERFORMANCE SEISMIC-RESISTANT BRACED FRAMES

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Abstract. Traditional seismic design philosophy attempts to concentrate permanent damage in selected "sacrificial" regions after earthquakes. However, damaged buildings are often demolished after earthquakes because too large residual deformation makes repair economically unviable. As a high-performance metallic material, superelastic shape memory alloys (SMAs) are appealing to the earthquake engineering community because their flag-shaped hysteresis can minimize post-earthquake residual deformation and enhance structural repairability. This presentation will highlight the research on seismic applications of superelastic SMAs, with a focus on seismic performance, seismic design, and life-cycle cost of self-centering braced frames. The results show superelastic SMAs can provide a promising solution to high-performance resilient structural systems.

SEISMIC PERFORMANCE EVALUATION OF STAINLESS STEEL FRAMES

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Abstract. The application of stainless steel in construction industries is increasing for its environmental and mechanical advantages such as corrosion resistance, pleasant in appearance, higher ductility, and low maintenance cost. The stress-strain curve of stainless steel is different from that of ordinary carbon steel. Stainless steel specially, Austenitic and Duplex grade exhibit higher strain hardening and ductility compared to that of carbon steel. The currently available design guidelines for stainless steel such as SEI/ASCE-8-02, AS/NZS 4673, and EN, 1993-1-4 generally supplement or modify the equivalent carbon steel provisions. However, none of these codes accommodated the advantages of stainless steel in seismic performance. Currently, values of response modification factor (R) recommended for carbon steel frames are being used for stainless steel structures, which undermines the benefits of stainless steel and makes the design more conservative. To incorporate the advantageous properties of stainless steel, determination of R values for stainless steel frames is necessary. Here, the seismic performance of different stainless steel frames such as Moment Resisting Frames (MRF) and Concentrically Braced Frames (CBF) was investigated. To evaluate the response of stainless steel frames, the performance of individual member such as beam, column and bracing under cyclic loading was evaluated. Later, behaviours of individual members were used in pushover analysis of frames. The study showed that the uses of stainless steel enhance the seismic performance of steel frames. It is also observed that the R values recommended in code may be increased for stainless steel frames.

Keywords: Stainless Steel, seismic performance, response modification factor, moment resisting frame, concentrically braced frame.

SMART METHOD OF FRP LAMINATES FOR SHEAR STRENGTHENING OF RC BEAM: RESEARCH TO PRACTICE

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Abstract. Externally bonded method of Carbon Fibre Reinforced Polymer (CFRP) laminate has been widely used for shear strengthening of reinforced concrete beam. Because of low bond strength of concrete, CFRP laminate used to debond at concrete-adhesive interface with lower strain as compared to its ultimate strain. The laminate could also debond with concrete cover seperation after yielding of internal shear reinforcement because of strain incompatibility behaviour between elastic stiff nature of CFRP laminate and plastic deformation of steel shear reinforcement. Interfacial debonding could be eliminated through appropriate design of laminate with simple mechanical embedded connector anchor system, however, cover seperation failure could not be eliminated through anchor systems rather than replacing of CFRP with elastic soft FRP material. In this regard, natural Jute Fibre Reinforced Polymer (JFRP) laminate would have huge potentiality. The main aim of the research was to present guidelines for shear strengthening of RC beam using CFRP and JFRP laminates with embedded connector anchor systems. The parameters of guidelines had been analyzed through experimental investigations on shear strengthened RC beams. Results showed that the cross sectional area of CFRP and JFRP laminates obtained from the design guidelines enhanced the maximum shear capacities of strengthened beams. Both CFRP and JFRP laminates strengthened beams had almost similar shear failure loads, failed after yielding of shear and flexural reinforcements without debonding of laminates. The presented design guidelines could be used in practice for shear strengthening of existing RC structures.

Keywords: CFRP and JFRP laminates, externally bonded, shear strengthening, design, embedded bar anchor

AXIAL, SHEAR, AND BENDING RESISTANCE OF PRETENSIONED SPUN PRECAST CONCRETE (SPC) PILE

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Abstract. Pretensioned Spun Precast concrete (SPC) pile has become a popular solution for deep foundation systems for its easier installation, higher bearing capacity, and overall cost-effectiveness. They are manufactured by pretensioned prestressing technique and are often formed by utilizing centrifugal force with an autoclave curing process. Though SPC piles have been widely used in China, Japan, Malaysia, and India for the last three decades, their commercial application is quite new in Bangladesh. Recently, Bangladesh Machine Tools Factory (BMTF) launched a large-scale SPC pile manufacturing plant. To ensure production quality and code compliance, they have started a research collaboration with the Civil Engineering Department of MIST. In this research program, the axial, shear, and bending resistance of SPC piles have been investigated for reclaimed areas of Dhaka. Primarily, pile load tests were conducted on the actual ground of the Jolshiri area to investigate the axial bearing capacity of SPC piles. After conducting strength tests for concrete cores and strands used in the actual pile, they were also tested at the laboratory under eccentric loading conditions to understand the structural capacity. Subsequently, the research program has been extended to examine the shear and bending resistance of SPC piles through the experimental four-point loading tests. A series of 3D finite element (FE) models have been developed to simulate the actual test conditions. The numerical results obtained through the FE analysis are validated with the experimental investigation and both results are compared with existing codes and guidelines. A parameter dependency study was also performed to understand the influence of spiral spacings, longitudinal strands, concrete grade, strand orientation, and thickness-to-diameter ratio on the shear and bending resistance of SPC piles. The outcomes of this research are expected to offer useful technical information for the axial, shear, and flexural design of SPC pile that will demonstrate its practical application for the deep foundations in the soft grounds.

Keywords: SPC Pile, Axial, Shear Capacity, Flexural Capacity, Pile Load Test, Finite Element Analysis

EFFECTIVENESS OF VETIVER GRASS ON HILL SLOPE EROSION AND DRAINAGE SYSTEM OF CHATTOGRAM METROPOLITAN

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Abstract. The Chattogram City Corporation area is dominated by hilly terrain and vulnerable to slope erosion and sediment loss due to rapid urbanization. The use of vetiver grass in this terrain is very effective in minimizing soil loss and increasing resistance against slope erosion. This study focuses on quantifying hill slope erosion and the effects of sedimentation in city drainage systems for both bare and vegetated conditions. Three vetiver-planted and one bare-slope plots were developed in the core area of the city at Tigerpass Hill. The average texture of all four hill plots was silty-loam (CL-ML), with low organic matter and an average slope angle of 34.80. After vetiver grass plantation in the developed plots, an average of 5% to 20% canopy coverage at different locations of an individual vetiver plot was noticed at the age of 66 to 74 days. Vetiver root networks developed within the age of 69 days in the dispersive surface soil zone exhibited a positive impact on slope erosion reduction. Sediment yield in three vetiver slope plots decreased significantly in the last observation year (2021), from the highest 73t/ha in Plot 3 to as low as 12 t/ha in Plot 4, albeit average rain increased 2 to 10 times that of the initial observation year (2019). In the first year (2019), for an average of 13.11% vetiver root coverage within surface soil, the average sediment yield on vegetated slopes was 62.67t/ha. In the third year (2021), average root coverage reached 43.93%, and average sediment yield dropped to 17.67t/ha. That means after a period of two years for an average 3.35 times increment of root coverage, the average sediment yield declined to 3.4 times from the initial condition, even though a 2.4 times monthly rainfall increment took place in the last year (2021). In order to arrest sediment at the source, 27 silt traps with an average total volume of 70,000 m^3 were planned to be installed by the city development authority. The use of vetiver on hilly slopes reduced sediment to a manageable quantity within the planned volume of silt traps. Thereby, sediment transport to the city drainage system and subsequent deposition are expected to be minimal, which would not cause congestion in the city's primary drainage system. Vetiver may effectively influence the urban drainage system surrounded by hilly areas with reliable performance and economy without involving common engineering structural measures.

Keyword: Soil erosion; sediment drop; vetiver; rainfall intensities, silt trap, sediment

SEISMIC FRAGILITY ASSESSMENT OF MULTISPAN RC BRIDGES USING GENERATIVE ADVERSARIAL NETWORKS OF MACHINE LEARNING

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Abstract. Highway bridges, as the lifeline structures, should be safe against extreme hazard, e.g., earthquakes and should also be functional after the event due to emergency needs. Seismic fragility assessment is widely used for pre-earthquake hazard management planning and post-earthquake damage and loss assessment. For the deveopment of fragility curves nonlinear dynamic time history analyses are usually performed which is computionally very expensive. As a results, seismic fragility curves for civil structures are generally depeloped from the resluts of dynamic analyses using limited number of ground motion records. To overcome this issue, generative adversarial networks (GANs), an approach to generative modeling using deep learning methods, and an upsupervised learning task of machine learning, can be used to generate synthetic analysis data with the results of limited analyses of structures. The present study deals with fast seismic fragility assessment of multispan reinforced concrete curved highway bridge with the use of synthetic analyses data generated by GANs. Limited number of incremental dynamic analyses (IDA) were performed using selected far field earthquake ground motion records. Displacement ductility demand of piers and shear strain of bearings were considered as engineering demand parameters for the development of component fragilities for four selected damage states. Bridge system fragilities generated with response data from IDA and synthetic data from GANs are represented for comparison. The outcome of the present study shows that the data from GANs can be useful for fast seismic fragility assessment of structures with limited analyses data which will be computationally efficient.

Keywords: Seismic fragility, reinforced concrete bridge, machine learning, artificial neural networks, generative adversarial network.

SHAPE MEMORY ALLOYS FOR MULTI-HAZARD RESILIENCY OF HIGHWAY BRIDGES

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Abstract. Reinforced concrete (RC) bridges are currently designed to withstand severe natural and man-made hazard without collapse, but damage of concrete and yielding of reinforcing steel bars are allowed. Excessive damage increases downtime, and sometimes the structure is beyond the repair stage and must be replaced. In recent years, shape memory alloy (SMA) rebars have been widely employed to improve the performance of concrete structures and reduce their permanent deformations, especially when subjected to seismic and extreme loads. Although the effectiveness of SMA as reinforcement in seismic resistant design is well documented, performance of SMA-RC bridges under various multi-hazard scenario is not well understood. To investigate the resiliency of RC bridges against multi-hazard scenarios, this paper discusses the performance of SMA-RC bridges under three extreme loading scenarios such as earthquake, vehicle collisions, and extreme wave loads. This study will present the details of the vehicle collision and wave load simulation in finite element environment. The results will be compared with conventional Steel-RC bridges under similar loading conditions. The outcomes of this study will aid in understanding the advantages of SMA as longitudinal reinforcement for improving the multihazard resiliency of highway bridges.

Keywords: Shape memory alloys, highway bridges, multi-hazard, resiliency.

INFLUENCE OF FIRE RESILIENCE REQUIREMENT ON THE SUSTAINABILITY OF CONCRETE SLABS

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Abstract. Concrete is one of the most widely used construction materials, with cement being a key component. However, cement production is associated with a significant carbon footprint. To address this issue, there is a growing demand to partially replace cement with less carbon-intensive binders to create sustainable concrete structures. The chemical composition of these new binders changes the fire resilience requirement of sustainable concrete, which affects the design of concrete slabs. Consequently, changes in concrete volume and cement quantity are expected in the construction of sustainable concrete slabs. This study aimed to investigate how the changes in fire resilience requirements influenced the changes in concrete volume and cement requirements for slab construction. The study involved designing numerous concrete slabs with different spans, loads, and durability conditions as per standard, focusing on minimizing the slab thickness. The slabs were then redesigned to meet various fire resilience requirements, and the changes in concrete volume and cement content were compared with the standard design. The study's findings indicated that changes in fire resilience requirements significantly affected concrete slab design, leading to adjustments in concrete volume and cement quantity. Therefore, the study highlighted the importance of considering fire resilience in the design and construction of sustainable concrete structures with implications for the cement industry and construction sector, which are significant contributors to global carbon emissions.

Keywords: Fire resilience, sustainable concrete, slab design, carbon reduction.

CLIMATE RESILIENT DESIGN OF CIVIL INFRASTRUCTURAL SYSTEMS

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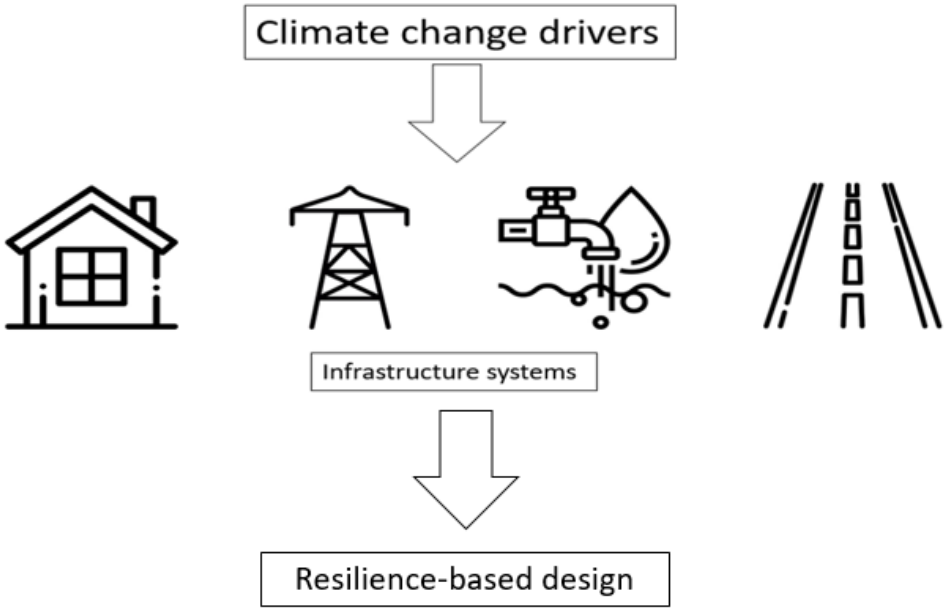
Abstract. Climate change poses significant challenges to the resilience and functionality of civil infrastructural systems, which are critical for supporting societal needs and economic development. The concept of climate resilient design has emerged as one of the crucial approaches to mitigate the impact of climate change on infrastructure and enhance their adaptive capacity. This talk provides an overview of climate resilient design principles and their application in civil infrastructural systems.

Climate resilient design involves integrating climate change considerations into the entire life cycle of infrastructure, including planning, design, construction, and operation. It requires a comprehensive understanding of the potential climate hazards and their adverse impacts on infrastructure, such as increased temperatures, sea-level rise, extreme weather events, and changing precipitation patterns. By incorporating climate projections and risk assessments, resilient designs can account for these impacts and minimize vulnerability. Key strategies for climate resilient design include enhancing the robustness and redundancy of infrastructure systems, diversifying and decentralizing critical services, adopting nature-based solutions, and incorporating adaptive management approaches. These strategies aim to increase the capacity of infrastructure to withstand and recover from climate-related disruptions, while also maintaining functionality and minimizing economic losses.

Furthermore, climate resilient design emphasizes the importance of interdisciplinary collaboration, stakeholder engagement, and long-term planning. It encourages the integration of climate science, engineering expertise, socio-economic considerations, and policy frameworks to develop sustainable and adaptive solutions. Additionally, it highlights the need for flexible design standards and regulations that can accommodate changing climate conditions and evolving knowledge. Implementing climate resilience-based design principles requires a paradigm shift in traditional engineering practices. It necessitates a proactive approach, considering both current and future climate scenarios, and prioritizing adaptive measures to ensure the longevity and effectiveness of infrastructure systems. By embracing resilience-based design, civil infrastructural systems can not only withstand the challenges posed by climate change but also contribute to the overall sustainability and well-being of communities.

In conclusion, climate resilient design offers a holistic framework for developing robust and adaptive civil infrastructural systems in the face of climate change. By integrating

climate considerations, engaging stakeholders, and adopting innovative strategies, infrastructure can enhance its resilience, reduce vulnerability, and continue to meet the needs of society in a changing climate.



DEVELOPMENT OF A NEW PAVEMENT PERFORMANCE MODEL AND ITS APPLICATION

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Abstract. Pavement condition assessment is important to determine maintenance needs, predict pavement performance, prioritize candidate projects, and establish budget plans. The condition of the pavement can be determined in various ways. However, approaches to pavement performance evaluation are generally divided into two categories: subjective and objective. Subjective ratings are related to distress ratings from trained raters. On the other hand, objective assessment is done by objective means, e.g., International Roughness Index (IRI), Semi-Automotive Roughness Index, etc. Although objective measurement can show pavement performance in detail and accurately, the subjective method is still more popular among local authorities for many reasons, mainly because it is more straightforward and cost-effective. The number of candidate projects in local agencies is often more than the fund allocated to them. In many cases, candidate projects are approved based on subjective assessments of government officials, and sometimes politically motivated. Considering these cases, this paper has proposed a new pavement performance model that is easy to develop, requires minimal cost and technical expertise, and uses feedback from road users. As a case study, responses from the residents of 53 municipalities of Newfoundland and Labrador, Canada, were used to develop the model and later verified with field data. A demo smartphone application was also developed to make the process more convenient.

Keywords: Pavement, PMS, Agencies

TALL WOOD AND HYBRID BUILDINGS WITH INNOVATIVE STRUCTURAL CONCEPTS

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Abstract. Tall wood and hybrid buildings have been emerging as the latest additions to skylines in increasing number of cities in North America, Europe, East Asia, and Australasia. There are also significant number of older wood buildings that are currently in the process of being retrofitted to current standards to prolong their service lives. To meet the challenges associated with the new and existing structures, attempts have been made to apply some innovative ideas developed for similar structures with other materials. This paper describes three such initiative: tubular structure for a tall timber-concrete hybrid building, design of outrigger-belt truss system for a tall building structure with timber, concrete, and steel combined and articulation of energy dissipating mechanisms for retrofit of soft-story wood buildings in seismic regions. The tubular structure is a virtual alternative to the 24-story high current tallest wood building. The outrigger-belt truss system is for a 20-storied wood building with two alternatives for the core: concrete and steel braced frame. The soft-story wood structure represents thousands of similar buildings in Western United States. Details of the analyses and designs are presented with results from numerical analysis. Some limitations and practical considerations are also discussed.

Keywords: Tall buildings, wood, hybrid structures, tubular systems, outrigger-belt trusses, soft-story buildings, seismic retrofit.

VETIVER GRASS TECHNOLOGY FOR CLIMATE RESILIENT SUSTAINABLE INFRASTRUCTURE AND DISASTER RISK REDUCTION

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Abstract. Bangladesh, a low-lying delta formed with recent deposits, is vulnerable to natural disasters. Continuous erosion, embankment failures, and landslides are exacerbated by climate change. Vetiver Grass Technology (VGT) has emerged as a cost-effective nature-based solution to address these challenges. Since 2008, the author has dedicated his career to enhancing and promoting this technology through extensive research. The author's research aims to address gaps in the existing literature by developing proper design, construction processes, and contracting methods considering geo-environmental variables. The research encompasses vetiver species identification, growth, rooted-soil characterization, and utilization of vetiver roots and shoots for reinforcement. This knowledge has been applied to cases including vetiver grass alone or in combination with geo-jute, hollow CC blocks, fly-ash stabilized soil, and application in various geographical areas for constructing climate-resilient infrastructure, such as, road, flood and coastal embankments, canal banks, hill slopes, char land protection and reclamation, etc. Through collaboration with government and international organizations, the author has incorporated VGT in numerous projects both locally and globally, such as Cambodia and Indonesia. The author has extended his research into IoT integration, genetic diversity studies, lake restoration and handicraft manufacturing. Workshops and training sessions have been conducted, presentations were made at seminars and workshops, and provided consultations have been provided to spread the acquired knowledge at home and abroad. These efforts have motivated policymakers, engineers, academicians, media personnel, students, NGOs/INGOs, government and international officials to embrace VGT to achieve the SDGs. The vetiver scheme has been included in procurement schedules of government departments like LGED. The extensive research has enriched the existing knowledge bank with technical papers, reports, guidelines, and knowledge products. Therefore, the author has made a significant impact, demonstrating the effectiveness of VGT in implementing NbS and contributing to disaster risk reduction and sustainable development. The author's future vision entails scaling up VGT for climate change adaptation, disaster mitigation, community development, and achieving public good and SDGs through capacity building and comprehensive approaches.

STRUCTURAL BEHAVIOR OF DEFICIENT STEEL AND ALUMINUM TUBULAR MEMBERS RETROFITTED BY CFRP SUBJECTED TO IMPACT LOADING

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Abstract. Tubular structural members made of steel and aluminum is often prone to structural deficiencies, caused by corrosion and collisions with vehicles or ships, both onshore and offshore. As a result, these degraded members are highly susceptible to severe damage and can lead to the collapse of structures under transverse impact loads. Carbon Fiber Reinforced Polymer (CFRP) is one of the most promising composite materials for strengthening of aluminum and steel tubular structures. To address these concerns, CFRP has emerged as an attractive and effective solution for strengthening structurally deficient hollow section. The aim of this research is to investigate on structural performance and behavior of metallic box section strengthens by CFRP composites under web impact loading. An extensive test programs have been conducted to strengthen the metallic tubular member by CFRP composites under impact loading. A total of twelve box sections were tested in a drop hammer impact testing setup, including one non-strengthened reference member and eleven CFRP-strengthened members with different lengths and orientations. The findings of this research provide valuable insights when subjected lateral impact loading which having 4-6.5 m/s velocity. For aluminum, stainless steel, and mild steel tubular sections, the results showed that the deformation of CFRP-strengthened box sections was reduced by 30.23%, 14.18%, and 7.40% for stainless steel, aluminum and mild steel tubular sections, respectively. The results indicate that the use of CFRP strengthening enhances the impact resistance capacity of the tubular sections by decreasing side deformations up to 30.23% compared to unstrengthen aluminum tubular specimens. Based on the experimental results, it can be revealed that the use of CFRP strengthening is an effective method for improving the performance of structurally deficient steel tubular members under impact loading.

Keywords: Steel and Aluminum tubular section, CFRP, Strengthening, Structural Behavior, Impact Loading

AN ALTERNATIVE AGGREGATE FOR SUSTAINABLE CONCRETE

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Abstract. In the near future, it is projected that widespread plastic manufacture and consumption will have a significant environmental impact. Plastic waste dumped in landfills can be processed and recovered as aggregates for concrete through subsequent processing. Plastic waste has already been used as aggregate in concrete in several studies. Before using it in structural concrete, though, more research is needed. This study will look at both static and dynamic behaviour to better understand the static and dynamic behavior of concrete constructed with polypropylene plastic aggregate (PPA) derived from waste plastic materials. In this work, PPA is used to partially replace natural coarse aggregate (NCA) and recycled concrete aggregate (RCA) and drop impact tests are conducted after the samples have been exposed to room temperature and increased temperatures (200°C and 400°C). PPA is being replaced in percentages of 0%, 5%, 10%, and 15%. The drop impact test uses both cylindrical and beam specimens. Investigations into various mechanical and durability tests are conducted. With an increase in PPA percentage at room temperature, the impact energy drops by up to 68%. Additionally, the impact blasts drastically reduce (6–13 no) when the specimens are heated to 200°C and 400°C. After being heated to 200°C and 400°C, the 15% NCA replacement cylinder loses impact energy by 87% and 91%, respectively. Because PPA is present in concrete, there is less damage as measured by mass loss, which is larger for the control cylinder than for PPA cylinders. The 5% PPA-based concrete has a comparable higher strength than the control concrete in terms of mechanical parameters. Depending on the concrete's age and the type of coarse aggregate used, a 5% PPA content can boost compressive strength by up to 11.6%. Regarding durability characteristics, all-natural PP concrete (NPC), recycled PP, and PPA have an increased tendency to absorb water.

Keywords: Polypropylene plastic aggregate, Recycled aggregate, Elevated temperature, Mechanical properties, Durability properties, Drop weight impact test.

STABILIZATION OF EXPANSIVE SUBGRADE SOIL USING INDUSTRIAL BY-PRODUCTS: ROLE OF ACTIVATORS

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Abstract. Utilizing industrial by-products for the construction of highways may be an efficient solution to the challenges associated with their disposal. There are currently two coal-based power plants operating in Bangladesh, and seven more are under construction. Approximately 0.08 tons of fly ash produced annually at the Boropukuria coal-based power plant in Bangladesh require huge disposal sites and create environmental problems. Moreover, a huge amount of slag is produced from the steel re-rolling factories. Additionally, a lot of fly ash is generated from medical waste incineration. This paper reports the results of the strength and physical properties of expansive soils stabilized by coal based fly ash, medical waste incineration ash, and ladle furnace slag. Natural and artificial soils with different degrees of expansiveness are used in the study. Various activators, including cement, sodium hydroxide, and sodium silicate, are used along with the ashes to improve the strength of the soil. A series of laboratory tests are carried out to find the chemical composition, particle size distribution, Atterberg limits, maximum dry density, optimum moisture content, soaked CBR, unconfined compression strength, and swelling index. The study finds that the unconfined compressive strength of the soil improves by 3 to 6 times after stabilization. Moreover, the soaked CBR value of the soil improves significantly. It is observed that strength improvement by low-calcium based-fly ash is not adequate. It needs activators to promote the chemical reactions that form the cementing gel. The study finds that the expansiveness of the soil is completely removed after stabilization with fly ash and activators. The outcome of this study may guide road engineers in Bangladesh to use industrial-by products with an appropriate activator for stabilizing subgrades with swelling potential.

Keywords: Industrial by-products; expansive soil; activators; unconfined compressive strength; soaked CBR

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A REVIEW ON COMPRESSIVE STRENGTH OF MASONRY

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Abstract. A test database of the compressive strength of masonry units and masonry prisms has been developed through a detailed literature review. The test results are compared with the compressive strength of similar masonry walls/prisms predicted by the design equations of the Australian masonry standard. It can be seen that the design equations of the Australian masonry standard often overpredict the compressive strength of masonry. A simple equation developed through a regression analysis of the test results is proposed, which can be useful in estimating the compressive strength of masonry from the compressive strength of the unit.

Keywords: Compressive strength, Masonry, Australian standard, Mortar.

PERFORMANCE BASED CONCRETE MIX AND COVER DESIGN IN SALINE EXPOSURE: WHY AND HOW?

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Abstract. RC structures, in general, are susceptible to chloride induced corrosion in saline/marine exposure due to their inherent permeability characteristics. The corrosion initiates within a RC element once the chloride concentration at the surface of embedded reinforcement reaches to a critical value. Such initiation of corrosion is usually minimized following two techniques - (i) by reducing rate of diffusion of chloride ions through concrete matrix and (ii) by providing adequate cover so that chloride ions would require longer travel distance to reach the surface of embedded rebars. Chloride diffusivity is usually reduced by selecting proper binder types that would guarantee long term pore refinement through pozzolanic reactivity. In case of cover requirement, it should be designed considering both construction feasibility and economy. Hence, in order to ensure design service life of a RC structure in saline conditions, a concrete mix needs to be properly proportioned with appropriate binder types that would kept the required cover values within feasible limit. A performance based design approach can ensure such suitable combination of concrete mix proportions and cover requirements. However, no performance based guidelines for marine concrete is available in Bangladesh focusing specific demand of the country. Considering the significance of the subject matter, an attempt has been made in this article to discuss the importance of performance based design and techniques to achieve it based on outcomes of the previous studies.

Keywords: Reinforced Concrete, Chloride Diffusivity, Corrosion, Performance Based Design, Saline Exposure, Cover Requirements

STRUCTURAL HEALTH MONITORING FOR RESILIENT COMMUNITIES

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Abstract. Resiliency refers to the ability of a community to overcome disruptions and return to a normal state following a hazardous event (e.g., hurricane, earthquake, or tsunami). There is a strong consensus among researchers that an essential element of resiliency is the preparation for and conduct of the rapid and efficient assessment of the post-event situation that includes the assessment of buildings, critical infrastructures, utilities, communication systems as well as the economy and the overall well-being of the community. The assessment of buildings and infrastructures falls into the structural health monitoring (SHM) field. This paper presents two ongoing efforts that can improve a community's resiliency through SHM. The first is the Human-Machine Collaboration Framework for Seismic SHM, which focuses on using acceleration data to make rapid post-earthquake decisions. The second is the development of a robust wireless printed strain sensor for large-area SHM, which addresses the challenges of instrumentation of large structures such as bridges or pipelines.

Keywords: Structural Health Monitoring, Seismic Resiliency, Human-machine Collaboration, Printed Strain Sensor.

UNLOCKING THE FUTURE: SYNERGIZING MACHINE LEARNING AND BIOMECHANICS FOR ADVANCING STRUCTURAL ENGINEERING

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Abstract. The integration of machine learning and biomechanics in structural engineering holds immense potential for addressing both the health challenges of construction workers and the critical need for accurate earthquake analysis and prediction. Biomechanics provides a valuable framework for addressing worker health challenges by analyzing physiological demands and ergonomic factors associated with construction tasks. This knowledge facilitates the development of efficient work environments, reducing physical strain, minimizing injury risks, and optimizing worker performance. Machine learning techniques complement biomechanical investigation by enabling accurate earthquake analysis and prediction. By analyzing seismic data, machine learning algorithms identify patterns and correlations, leading to more precise earthquake predictions. This information aids in decision-making regarding structural design, retrofitting measures, and emergency response planning. Additionally, machine learning algorithms enhance structural health monitoring systems, enabling early detection of potential failures and timely preventive measures. The integration of machine learning and biomechanics addresses two critical aspects of structural engineering. It prioritizes worker health by developing efficient work environments, and it enables accurate earthquake analysis and prediction, enhancing structural safety and resilience. This synergistic integration offers transformative possibilities, improving worker health and safety while advancing seismic resilience.

Keywords: machine learning, biomechanics, structural engineering, optimization, predictive modeling, data-driven approaches.

SUSTAINABLE CONCRETE AND RESILIENT RCC STRUCTURES - ESSENTIAL FOR ECONOMIC GROWTH OF BANGLADESH

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Abstract. Bangladesh is now a Lower Middle-Income country and aspiring for further economic development. To achieve that goal, Bangladesh is currently experiencing a period of rapid infrastructure development where projects like long span bridges (Padma Bridge, Jamuna Rail Bridge), Sea Ports (Matarbari, Payra), Power Plants (Payra, Banskhali, Rooppur), Economic Zones, Public Transports (Flyovers, Metro Rail) are undertaken. However, amidst this development, the need for sustainable and resilient structures has become increasingly critical to address environmental concerns, resource efficiency, and the challenges posed by climate change and disasters. This presentation aims to explore the pressing need for sustainable and resilient infrastructure in Bangladesh, with a particular focus on the construction industry's growth, the demand for raw materials, and the escalating risks associated with climate change impacts. It also underlines the necessity for sustainable structures that incorporate eco-friendly practices and prioritize resource efficiency. It discusses the utilization of industry waste, i.e., Fly Ash (from Coal Fired Power Plants), Rice Husk Ash, and Ground Granulated Blast Furnace Slag (from Steel Rerolling Mills) in the form of Supplementary Cementitious Materials (SCM), and recycled aggregates (brick and stone) from demolished structures as an alternative of aggregates for concrete production. These options are highlighted as cost-effective, locally available, and sustainable alternatives. Furthermore, the importance of resilient structures in the face of climate change and mounting salinity issues in coastal areas of Bangladesh is emphasized. The presentation explores the potential use of indigenous fibers (nylon, jute, GI wire, and coconut) and SCM (FA, GGBS, RHA) as strategies to enhance resilience and durability of concrete structures in Bangladesh.

Keywords: Supplementary Cementitious Material, Fiber Reinforced Concrete, Durability

U-SHAPED HYSTERESIS SMA DAMPER FOR SEISMIC ISOLATION: A NUMERICAL STUDY

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Abstract. Energy-dissipating dampers is an effective way to reduce the response of civil engineering structures to earthquakes. Hysteretic dampers are extensively used as energy dissipation device to control the deformation in the structural system. In this direction, shape memory alloy (SMA) has unique recentering capacity which shows a flag shaped hysteresis behavior and offers higher serviceability when used in the building. This research proposed a metallic yielding damper that utilizes this smart metal for creating the shape memory alloy U-shaped Damper (SMA-UD) with a trapezium cross-section. The trapezoidal shaped U-damper (T-SMA-UD) was compared with the conventional rectangular cross-section under in-plane and out-of-plane cyclic loading. The yield strength, yield force (f_y), yield displacement (δ_y), initial stiffness (K_1), post-yield stiffness (K_2), stiffness ratio (α), and energy dissipation capacity (E_d) of the suggested and traditional SMA-UD were studied and compared using numerical finite element (FE) analysis. The thickness, height, and width of the T-SMA-UD were adjusted as such that their cross-sectional area remains the same as that of standard rectangular shaped U-plate damper. The suggested change in shape produced an optimum-shaped U-damper with considerably increased energy dissipation and deformation capabilities compared to that exists in the literature.

Keywords: Energy dissipation, hysteretic damper, shape memory alloy, U-shaped damper.

NUMERICAL SIMULATION OF RESIDUAL STRESSES IN STRUCTURAL STEEL MEMBERS

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Abstract. Structural steel members develop residual stresses due to manufacturing and fabrication processes. Depending on size and welding procedure, the magnitude and distribution of these residual stresses can vary significantly in members. Hence, it is challenging to accurately predict the magnitude and distribution of residual stresses in steel structural members and connections which can substantially affect their structural performances including global and local flange-buckling strengths, seismic performances, and low-cycle fatigue responses. Residual stresses are either ignored or a simplified distribution is assumed in the analysis and design of structural members. This paper presents a numerical scheme to simulate multiaxial residual stresses in structural steel shapes by using a sequentially coupled thermo-mechanical analysis. Residual stresses due to non-uniform cooling after hot-rolling and welding processes are simulated. The analysis considers the effects of phase transformation, the material heterogeneity in the heat-affected zone induced by welding, and the weld sequence. The simulation technique is validated against several experimental responses demonstrating the robustness of the simulation scheme. The numerical scheme developed provides an advanced experimentally validated technique for simulating multiaxial residual stresses in structural steel shapes for use in structural analysis and design of moment-resisting connections and frames.

Keywords: Initial Residual Stresses, Weld Residual Stresses, Numerical Simulation, Structural Steel Member, Thermo-Mechanical Analysis.

DEVELOPMENT AND PERFORMANCE EVALUATION OF GEOPOLYMER CONCRETE INCORPORATING FLY ASH, GGBS, AND GRAPHENE NANOPLATELETS

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Abstract. This paper investigates a one-part geopolymer concrete (GPC) made with a combination of low calcium Fly Ash and Ground Granulated Blast Furnace Slag (GGBS). The objective is to develop a Portland Cement-free GPC with minimal energy-intensive alkali activators, resulting in a general use composite with a compressive strength exceeding 10 MPa. Additionally, the study explores the effects of specific grade grapehen nanoplatelets (GnP) on GPC at the nanoscale. The research includes testing of fresh properties, compressive strength, water absorption, and chloride resistance. An optimized GPC mixture achieved compressive strengths of 16.16 MPa at 8 days and 18.31 MPa at 34 days. GnP demonstrated promising enhancements to GPC, including a 54% increase in strength and a 13% reduction in water absorption capacity.

Keywords: Fly ash, GGBS, Geopolymer, Grapheme nanoplatelets, Mix design.

SUSTAINABLE CONSTRUCTION PRACTICES IN MEGACITY DHAKA: LOWERING CARBON EMISSIONS AND MEETING SDGs

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Abstract. The enhancement of environmental sustainability has identified infrastructure construction as a crucial domain, primarily due to its substantial energy consumption, which constitutes 40% of global energy usage, and its significant contribution to global glasshouse gas (GHG) emissions, accounting for one-third of the total emissions. Dhaka, a rapidly expanding South East Asian Megacity, relies significantly on the utilization of concrete infrastructure. The rapid urbanization and construction activities in Dhaka demand urgent attention to address the environmental implications linked to the construction sector, particularly its carbon emissions. This study, therefore, investigates the potential of sustainable construction materials in mitigating carbon emissions in Dhaka City and emphasizes the specific opportunities available for their adoption. Energy-efficient design reduces construction carbon emissions significantly. Recycled or repurposed materials, responsibly sourced timber, and concrete alternatives with a minimal carbon footprint should be used. Construction companies can reduce landfill waste and resource demand by recycling and reusing materials. Construction can conserve water by using water-efficient methods. Installing water-saving fixtures, rainwater harvesting systems, and low-irrigation landscaping are examples. Green roofs, living walls, and permeable pavements can sequester carbon, improve air quality, reduce urban heat island effects, and increase biodiversity in urban environments. Sustainable construction practices can be found and applied by addressing embodied carbon and building energy efficiency. Architects, engineers, contractors, and legislators must collaborate for sustainable construction. Together, they can promote sustainable practices, share expertise, and create creative carbon-reduction solutions. Through the implementation of sustainable construction practices, the infrastructure construction in Dhaka has the potential to achieve substantial reductions in carbon emissions, conserve valuable resources, and make meaningful contributions toward the attainment of various Sustainable Development Goals (SDGs). Notably, these goals include SDG 7, which focuses on the provision of affordable and clean energy, SDG 9, which emphasizes the development of industry, innovation, and infrastructure, SDG 11, which centers on the creation of sustainable cities and communities, and SDG 13, which addresses the urgent need for climate action. Adopting sustainable construction practices helps reach the Paris Agreement's goal of net zero carbon buildings and construction by 2050 and all new structures by 2030.

Keywords: Infrastructure Constructions, Carbon emissions, Sustainable Practices, Clean City

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VIBRATION ANALYSIS OF LIGHT RAIL TRANSIT (LRT) BRIDGE SUPPORTED ON ROCKING PIER(S) AND ISOLATED ABUTMENTS

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Abstract. Light rail transit (LRT) is a popular mode of transportation in modern metropolitan areas. In LRT systems, trains run on tracks over elevated guideways, streets, or combinations of both. The passengers inside the train feel vibrations due to the vibration of the train, tracks, and bridge while the train is running on the bridge/elevated guideway. In order to determine passenger comfort, vibration analysis is often required if a fundamental vertical flexural frequency of the bridge is less than 3.0 to 4.0 Hz (usually specified by the owner). Passenger comfort increases with decreasing vertical acceleration inside the train and vice versa. In accordance with Eurocode EN 1990:2002, Table A2.9, recommended levels of comfort (vertical accelerations) are usually followed. These levels of comfort and associated limiting values may be further defined by the owner for the individual project. Per Eurocode, vertical acceleration less than 1.0 m/s^2 is very good, and more than 2.0 m/s^2 is unacceptable. The vertical acceleration of the train is a function of vehicle speed, mass of the coach and bridge, and stiffness and damping of the primary and secondary springs of the coach, tracks, bridge, and soil. Therefore, train-track-bridge-soil interaction (TTBSI) analysis is required to determine the vertical acceleration of the train in other words passenger comfort. In this parametric study, a two span LRT bridge supported on rocking pier and isolated abutments is chosen to demonstrate these interactions; however, the TTBSI analysis is applicable for any conventional bridges.

This paper presents train-track-bridge-soil interaction analysis of a bridge. This study is intended to be a reference for bridge designers and owners to provide a step-by-step procedure for TTBSI analyses.

Keywords: Train-Track-Bridge-Soil Interaction, Vibration Analysis, Passenger Comfort, Vertical Acceleration, Rocking Pier, Isolated Abutment.

ASPHALTENE PRECIPITATION OPTIMIZATION THROUGH PARTIAL DISSOLUTION USING SI-SARA METHOD

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Abstract. Asphaltene is one of the key chemical species of bitumen and generally dictates its stiffness-building behavior. The separation of asphaltene from bitumen and its gravimetric as well as chemometric analysis paves the way for a better understanding of bitumen behavior. Asphaltene is generally precipitated from a solution of asphalt in a non-polar solvent (such as n-heptane) where more polar asphaltene precipitates from a solution. This study investigates the effectiveness of different solvent ratios of n-heptane/toluene solution, in separating asphaltene from bitumen due to changes in Hansen/Hildebrand Solubility Parameters. The experiment involved gradually varying ratios of n-heptane and toluene solvents such as 90:10, 80:20, and so on. A 50:50 solvent ratio was also examined to compare its effectiveness against using 100% of either solvent. Hansen Solubility Parameters were utilized to see the changes in different parameters due to the mixing of different solvents. The findings revealed that the solvent ratios influenced the asphaltene's gravimetric yield percentage. Remarkably, the 50:50 solvent ratio demonstrated comparable results to those achieved using 100% of a single solvent of n-heptane. This outcome highlights the potential for cost optimization as well as redundancy by reducing the amount of solvent required while maintaining the asphaltene separation efficiency. The gradual changes of asphaltene yield also indicate that asphaltene is not a single chemical element, but a distribution of molecules of varying polarity.

Keywords: SARA, Asphaltene, Partial Dissolution, Bitumen

COMPREHENSIVE STUDY ON CPT-BASED LIQUEFACTION VULNERABILITY ASSESSMENT: THE CASE STUDY OF ARAIHAZAR, BANGLADESH

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Abstract. Bangladesh constitutes a major portion of the Bengal Basin. The north-east trending Indian Plate and the Eurasian Plate are connected to the geologic development of the Bengal Basin. According to BNBC, the project site in Zone 2, which is the closest to the Madhupur fault, can produce an earthquake with a maximum magnitude of 7.5. Liquefaction followed by earthquakes has severely damaged underground pipeline lines around the world in recent times. Also, previous research has shown that pipeline damages in liquefaction zones are much greater than damages in non-liquefaction locations. This study focuses on the probable effects of earthquake induced liquefaction on buried pipelines. Liquefaction susceptibility and Liquefaction Severity Number (LSN) values were estimated using Cone Penetration Test (CPT) results. The LSN considers the effects of liquefaction by using the post-liquefaction volumetric strain as an index for a defined return period of ground motions. To assess this, initially the CPT-based triggering method proposed by Boulanger and Idriss (2014) was used to compare the Cyclic Stress Ratio (CSR) to the Cyclic Resistance Ratio (CRR) in the prediction of liquefaction susceptibility of the ground. Also, the Liquefaction Severity Number (LSN) offers elaboration regarding the potential liquefaction damage and earthquake induced settlement. The sensitivity analysis in response to the PGA for a range of 0.05 g to 0.30 g has been carried out to investigate the severity of the PGA for various earthquake magnitudes. This analysis indicates that for the range of PGA imposed by the recent earthquakes, the LSN vulnerability parameter provides a more consistent correlation. Moreover, these guidelines may be used to predict the damages of underground structures from future earthquakes. Finally, it will also facilitate the selection of suitable ground treatment methods, considering soil types and liquefaction severity.

Keywords: Liquefaction, CPT, LSN, CSR, CRR, settlement.

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CHARACTERIZING THE LONG-LASTING RESILIENCE AGAINST CORROSION AND VEHICULAR COLLISIONS FOR BRIDGES IN CANADA

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Abstract. Recent disasters and the escalating impact of climate change have raised urgent concerns about the ability of bridges in Canada to withstand the intensifying environmental stressors and extreme events brought about by these changes. The current research seeks to answer this question by evaluating the performance of concrete highway bridges in Ontario that are exposed to both episodic (vehicle-bridge collision) and chronic (corrosion) hazards in the context of climate change.

To achieve this goal, this research proceeds in three stages. First, site-specific exposure and climate conditions are incorporated to generate a series of 'Corrosion Hazard Maps'. These maps enable visualization of corrosion-induced reduction in serviceability for bridges across North America, contributing to the formulation of region-based climate change adaptation solutions. Next, nonlinear finite element approaches are employed to investigate the performance of corroding reinforced concrete (RC) bridges subject to heavy vehicle collision. Last, a performance-based collision safety risk assessment framework is created, implemented, and refined for bridges with RC piers. The framework is based on the notion that the collision safety risk of existing and new bridges can be effectively expressed to bridge owners and stakeholders using performance metrics (redundancy, ductility, and damage level) and visual devices (fragility curves). The generated results will assist in pre-accident preparation (bridge repair prioritization) and accident response (lane/road closure) in the event of truck impacts.

This research advances our understanding of how highway bridges respond to corrosion, climate change, and vehicle collisions. It enhances knowledge of bridge resilience in Canada and provides valuable guidance for effective infrastructure management and adaptation strategies. By addressing these critical factors, this research will contribute to the long-term safety and resilience of highway bridges, benefiting the broader field of transportation infrastructure worldwide.

LIFE CYCLE COST ANALYSIS ON AIRPORT PAVEMENT DESIGN WITH DIFFERENT TYPES OF MATERIALS

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Abstract. This paper evaluates the life cycle cost analysis of airport pavement design utilizing substitute layer materials. The pavement structural thickness design data collection includes (i) annual air traffic departures (ii) traffic growth factor (iii) sub-grade strength of 12,000 psi (iv) design life of 20, 30, and 40 years. FAARFIELD software is used to design multiple flexible and rigid pavements, and its alternative designs employ substitute layer materials prescribed by the Federal Aviation Administration. These pavements' initial construction costs are estimated taking into consideration the runway at Hazrat Shahjalal International Airport, Dhaka. Among them are cost-efficient pavements, which are anticipated to have a 40-year service life and incorporate overlay designs. Afterward, the life cycle costs were analyzed using the net present value (NPV) method and the AirCost LCCA software. This research identifies the most cost-effective pavement design materials. The life-cycle cost analysis shows flexible pavement has lower initial costs of 12.4%, 13.88%, and 14.93% but higher maintenance and rehabilitation costs of 7.82%, 8.73%, and 8.08% than rigid pavement. As a result, rigid pavement with a single Portland cement concrete overlay is the most cost-effective pavement choice (NPVs of 4.41%, 4.45%, and 3.73%, respectively, and AirCosts of 19.09%, 19.24%, and 18.45%) and has the best possibility of success with the least simplified risk. Moreover, a sensitivity analysis demonstrates that as the discount rate rises, the life cycle cost falls. This paper's findings will assist aviation authorities and policymakers in making calculative decisions about upcoming airport pavement development, maintenance, and rehabilitation projects.

Keywords: Life cycle cost analysis (LCCA), airport pavement design, substitute materials, net present values (NPVs), AirCost LCCA software, cost-effective pavement, FAARFIELD software.

PROPOSAL FOR THE CONCEPTUAL STRUCTURAL PROTOTYPE OF EMERGENCY SHELTER FOR THE VULNERABLE ROHINGYA COMMUNITY OF COASTAL CAMP OF BANGLADESH

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Abstract. The structural design of emergency shelters is important to ensure sustenance for the post-disaster period of the vulnerable Rohingya community. Bangladesh ranks fifth most disaster at-risk country and is more for giving shelter to 943,000 Rohingya inhabits till October 2022. This paper aims to propose a conceptual prototype for the emergency shelter considering both architectural and structural aspects. The structure will be resilient with a permanent and stable core to withstand cyclone hazards, while the additional bamboo structures can easily be constructed in the post-disaster period for temporary living. Locally available bamboo and structurally stable steel beams supplied by the government or non-profit organizations will be used as primary building materials. The methodology includes mixed methods of Site selection and analysis, Structure considerations, and Conceptual Design Proposal. The findings will show the structural strength of the proposed prototype due to the effect of a cyclone. The scope of this paper is a further stable shelter based on the given prototype that can be used for a more permanent structure with a higher lifecycle and resilience. The lack of a physical survey and real-scale structural analysis of the proposed design are identified as the paper's limitations. In conclusion, it can be said that the post-disaster shelter issue of the vulnerable Rohingya community should be tackled with expertise. A simulation-based prototype with a stable core and low-cost sustainable bamboo will give assurance to the temporary shelter.

Keywords: Structural design, temporary shelter, Rohingya community, disaster vulnerability.

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A NOVEL HEAT-TREATMENT TECHNIQUE FOR SEISMIC PERFORMANCE ENHANCEMENT OF WELDED STEEL MOMENT CONNECTIONS

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Abstract. This paper presents three seismic performance enhancement techniques for steel building moment connections. The first enhancement technique involves reducing the strength of steel over specified regions of the beam flanges by exposing the regions to high temperatures followed by slow cooling (annealing). This heat treatment technique reduces the strength of steel without changing its ductility, thereby promoting the development of the beam plastic hinge away from the beam-column connection welds. The second seismic performance enhancement technique involves stiffening the beam web in the plastic hinge region to delay the onset of local web and flange buckling resulting in the delay of strength degradation. The third performance enhancement technique involves removing the end plate stiffener and relocating the bolts of an 8-bolt extended end plate connection. Experimental responses of the modified moment connections demonstrated their performance enhancements. This paper summarized the modified connections and their improved performances.

Keywords: moment connections, HBS connection, EEP connection, beam web stiffening, beam plastic hinge, interstory drift.

A STUDY ON THE SAFETY HAZARDS IN THE CONSTRUCTION INDUSTRY OF BANGLADESH

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Abstract. The construction Industry in Bangladesh has experienced significant growth due to the country's improving socio-economic conditions. Despite this progress, the industry remains one of the most hazardous, with a high rate of work-related injuries and loss of lives. In spite of laws, regulations, and safety policies being implemented to protect workers and reduce casualties, very little progress has been made. This study aims to identify and rank the major safety issues at construction sites in ongoing projects across Bangladesh. The study is based on a questionnaire survey with engineers, workers, supervisors, development authorities, and consultants to obtain their perspectives on various safety hazards at construction sites. Statistical Analysis has been performed to assess the severity of various hazardous activities. Based on the study, recommendations have been made that would pave the way to reduce the number of injuries and fatalities. Moreover, the study focuses on identifying and mitigating the safety risks as well as providing guidance to the policymakers for reviewing and updating the existing regulations and policies and to enact new laws addressing modern day problems. Ultimately, the outcome of the study will contribute to improving the safety of the construction industry in Bangladesh, ensuring the well-being and protection of workers involved in these projects.

Keywords: Construction Industry, statistical analysis, questionnaire surveys, safety, development authority.

COMPARATIVE EFFECTIVENESS OF L-SHAPE & RECTANGULAR COLUMNS AROUND THE LIFT CORE FOR MODERATE & VERY SEVERE SEISMIC PRONE AREA IN BANGLADESH

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Abstract. After rectangular and circular columns, L-shaped columns may be the most frequently encountered reinforced concrete columns, since they can be used as a corner column in framed structures. Lift core walls plays a vital role in both regular and irregular shape building for strengthening the structure of high seismic zone areas. This study focuses the use of L shape and rectangular shape columns around the lift core in a G+6 storied building to resist the seismic and wind forces as well as the effect of the lift core is also taken into consideration. In this research work a comparative analysis have been carried out to find out the most effective shape column between L and rectangular with respect to moderate and severe seismic zone area according to BNBC-2020. Severity of seismic prone area is only considered for Bangladesh. Equivalent static method was used for the entire analysis by using FEM software ETABS-2016. The structural responses were measured in terms of lateral displacement, storey drift, drift ratio, time period for seismic load as well as drift ratio, displacement, sway at roof and time period for wind load. Considering the overall parameters, it can be concluded that using the L shape column around the lift core can be a good solution to reduce the displacements, drifts as well as to increase the stiffness of the structure.

Keywords: Lift Core, L shape column, Rectangular column, Equivalent static method, Effective shape, Seismic zones.

A COMPARATIVE STUDY ON THE APPLICATION OF SHALLOW FOUNDATIONS FOR SUSTAINABLE CONSTRUCTION IN RECLAIMED LANDS: A COMPARISON OF FIELD EXPERIMENT AND THEORETICAL RESULTS IN DHAKA, BANGLADESH

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Abstract. Reclaimed lands in Dhaka city suffer from aggravating construction problems such as settlement, liquefaction, and lateral spreading due to poor soil conditions. A shallow foundation can be a suitable solution as it distributes the building loads over a wider area, reducing the risk of structural damage. This research analyzes the carrying capacity of shallow foundations in reclaimed terrain with weak soil of soft to medium consistency, based on a static load case for a shallow foundation design at the Mirpur in the capital of Bangladesh, although a dynamic analysis is also required for typical foundations. This study also summarizes the practical and theoretical findings of an examination of the ultimate bearing capacity of the soil. A full-scale load test was conducted to determine the efficacy of the shallow foundation design in the reclaimed land of Dhaka, which is comparable to the site selected for low-rise or low-occupancy projects. The findings demonstrate that typical theoretical methods may not always produce correct forecasts of soil behaviour and that actual field testing is required to verify the soil's true carrying capacity. As a result, the study stresses the importance of exercising caution when relying entirely on theoretical estimates to calculate foundation capacity for sustainable construction projects. This study demonstrates that ground reinforcement can significantly increase the bearing capacity of shallow foundations, making them a more sustainable option for development on reclaimed land, especially when axial load scenarios are considered and can help practitioners and decision-makers to ensure sustainable and economical construction.

Keywords: Sustainable construction, reclaimed land, soil settlement

NUMERICAL ANALYSIS ON STRUCTURAL BEHAVIOR OF CONCRETE FILLED STEEL TUBULAR COLUMNS

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Abstract. Concrete filled steel tube (CFST) is the composite segment shaped by filling concrete into a hollow steel tube. Broad research has been conducted on CFST in recent years have demonstrated that the CFST areas have high malleability, quality and solidness properties. The experimental study is quite limited due to scarcity of laboratory facility and test time consumption. Therefore, this paper deals with the validation of the experimental data using numerical software ABAQUS to find the structural and confinement behavior of the CFST columns. A total of 15 CFST column specimens (stub and slender) have been taken with three different shapes which are categorized as circular, rectangular and square sections. The CFST columns were made with different concrete strength, slenderness ratio. The simulation results were verified with the experimental data. From the comparison, it is noticed that the numerical results can accurately capture the experimental results. It is also observed that the confinement on lower strength concretes were higher than the higher-grade concrete strength.

Keywords: Confinement, Circular concrete filled steel tubular column, Axial-compression, Flexural compression.

AVAILABILITY OF SEISMIC DATA AND EXISTING ATTENUATION LAWS IN BANGLADESH: A REVIEW

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Abstract. Earthquake history analysis is crucial for figuring out the level of probable seismic hazard in earthquake-prone geographical areas. More availability of data ensures more precise probabilistic estimation of parameters, especially peak ground acceleration, which is considered significant in time history analysis. From previous intense research and observation, it is understandable that Bangladesh is spatially vulnerable due to the presence of epicenters within and in the vicinity of this area. Moreover, four specific zones have been delineated, considering a range of earthquakes with varying magnitudes of different return periods. To represent both the design basis earthquake and maximum credible earthquake, seismologists are expected to provide the seismic data. Unfortunately, the lack of proper seismic equipment results in the unavailability of enough data on seismic records. Hence, a past database of nearby zones has been considered to develop acceleration time history for this region. Based on available records from the nearest sites, code specified process can be applied for selecting and scaling records. Zone-wise attenuation laws have been developed in different regions of the world depending on the soil types. Incorporating magnitude, frequency, and other designated parameters, peak ground acceleration (PGA) has been estimated using the proposed attenuation laws by the researchers. However, seismometers are sparsely distributed throughout the country, mostly in and around Dhaka, the capital city. This research paper overviews Bangladesh's earthquake data availability and the applicability of the existing attenuation laws. Furthermore, this study can provide directions for further studies for developing mathematical models with better performance considering the recent earthquake data. However, the validation will be more precise with the accessibility of seismic records.

Keywords: Peak ground acceleration (PGA), Time history, Epicenter, Return period, Attenuation.

IMPORTANCE OF ROAD SAFETY MEASURES IN SELECTED LGED ROADS USING STRUCTURAL EQUATION MODELING APPROACH

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Abstract. The Local Government Engineering Department (LGED) has built several roadways around Bangladesh to facilitate efficient communication. This study aims to identify the importance of road safety measures on selected LGED road to prevent accidents. For the study, a sample road section Binnadangi Zila Road (Basta)-Nowabganj Upazilla via Hatni Bazar, Maniknagar, located in Singair Upazilla of Manikganj district, is selected considering its present condition, placement of safety measures, and time frame. A Structural Equation (SE) model is developed with 150 data to identify critical accident causes. Additionally, the Relative Importance Index (RII) approach is used to assess the responses, strengthening the SE model. The study finds that among the two latent variables, "Safety" has more influence on road accident causes on selected LGED roads. Among the observed variables under the "Safety," latent variable 'Safety at adverse weather' has the most significance. If sufficient road safety measures are not taken in adverse weather, severe road accidents might happen. These critical causes need to be addressed to improve overall road safety performance. The decision-makers can use the findings to improve the road safety of LGED roads.

Keywords: LGED, Rural Road, Road Safety, Structural Equation Modeling, Relative Importance Index.

IMPACT OF FLOOD LOADING ON A REPRESENTATIVE STEEL GIRDER BRIDGE

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Abstract. To enhance the economic growth of a nation, efficient and affordable mobility of people and transportation of goods are essential. In this regard, highway bridges – one of the key components of highway transportation networks – play a pivotal role. Generally, bridges are designed to survive against design loading during the lifespan. However, unpredictable natural disasters such as extreme floods may endanger the safety and serviceability of bridges during their design life and produce a tremendous economic loss to the society they serve. This very important matter is currently being investigated by the structural engineering community, and more studies are required to develop a comprehensive knowledge base on the topic. In this relation, the study here considers a representative steel girder bridge and analyses its response under possible flood scenarios. Several bridge design provisions for floods are reviewed, and representative cases of flood load on the bridge are formulated. Numerical simulations for different flood-induced loading cases with various combinations of flood velocity and water height reveal that the flood vulnerability of the bridge increases with velocity and water level. The debris loading increases by 1.5 times its hydraulic pressure when they act concurrently. However, after a certain level of flood height, the hydraulic pressure does not change, whereas the debris pressure continues to increase with increasing water height. The outcome of this research provides a better insight into the problem and identifies key areas for future research to improve the failure probability of bridges under extreme floods.

Keywords: Flood loads, steel bridge, drag force, lift force, debris force.

FACTORS AFFECTING CONSTRUCTION DELAY IN DHAKA CITY

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Abstract. The construction sector often uses the phrase "delay." Dhaka City's construction sector has proliferated in recent years, but its growth has coincided with delays, which has had profound consequences for schedules, finances, and quality. The purpose of this research is to determine the causes of construction delays. The possible reasons for building delays have been identified, and a survey questionnaire has been designed after an exhaustive literature analysis and interviews with construction stakeholders. Twenty possible delay factors have been included in the questionnaire survey. The construction site was chosen considering the story number of the building. A total of 157 responses have been taken from different stakeholders (Engineers, Contractors, and Workers) from 8th to 15th-storied residential and commercial buildings in Dhaka city. The relative importance index (RII) equation was adopted to get the analysis result. Later, the rank was tabulated according to different stakeholder's perspectives. Among the 20 factors top factors are "Taking time in making decision By Owner" (F1, RII= 0.879), "Incomplete Design Before Commencement" (F13, RII= 0.866), "Lack of Skill of Engineers" (F6. RII= 0.864). The research findings will help the Dhaka city construction sector devise plans to deal with the causes of delays. Prioritizing the conclusions of this research by the construction industry in Dhaka city will minimize construction delay, hence boosting the construction industry in Bangladesh via the timely delivery of high-quality projects.

Keywords: Frequency Index (F.I.), Stakeholder perspective, Relative Importance Index (RII), Dhaka City, Construction Delay, Severity Index (S.I.)

NON-LINEAR FINITE ELEMENT ANALYSIS OF STEEL PLATE SHEAR WALL WITH DIFFERENT PLATE THICKNESS AND COLUMN SIZES

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Abstract. To withstand lateral stresses like wind and earthquakes, steel buildings require lateral load-resisting systems called steel plate shear walls (SPSW). The current study aims to analyze how different geometric and material characteristics affect unstiffened steel plate shear walls when subjected to cyclic loads. A three-dimensional full-scale finite element model for a single panel has been developed using finite element software to predict hysteresis behavior. The numerical model includes both geometric and material nonlinearities. The FE modeling approach has been verified through previous experiments. The current analysis and previous experimental results have demonstrated a satisfactory agreement, proving the validity and admissibility of the present model for further parametric study. By using non-linear monotonic, the investigation has then focused on studying the effect of using different column sections on an unstiffened single panel SPSW for varying thickness. The monotonic behavior, including the strength and load-resisting capacity of the SPSW with respect to the bare frame has been examined. The bare frame contributes more to the strength gain of a large column section whereas the thickness of the infill plate contributes more to the strength gain of a smaller column section system. A detailed discussion of the result is presented, along with a comparative analysis of the behavior of SPSW having different column sections and geometric configurations.

Keywords: Steel plate shear wall (SPSW), unstiffened, hysteresis behavior, nonlinearity, cyclic loading.

A SPATIAL-TEMPORAL ASSESMENT OF EARTHQUAKE VULNERABILITY USING ARCGIS IN DHAKA CITY

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Abstract. Earthquakes have significant societal consequences, including structural destruction, economic impacts, and loss of life. This highlights the urgent need for reliable studies on residential site safety and damage assessment in urban areas. In our innovative study, we delve into the complex relationship between seismic activity and urban regions, revealing the temporal and spatial sensitivity of cities to seismic shocks. Through the fusion of cutting-edge techniques and Geographic Information Systems (GIS), we present a remarkable methodology that evaluates earthquake susceptibility across time and space. The culmination of our efforts is visually captivating vulnerability maps, carefully crafted to depict the essence of vulnerability in the research area. These maps vividly illustrate vulnerability levels during different time periods, considering both occupational and residential density. Drawing from an innovative vulnerability scale, our comprehensive analysis enables effective disaster risk management strategies, empowering decision-makers to reduce losses and promote urban sustainability. This study transcends academic boundaries and has the potential for tangible real-world impact, contributing to our understanding of urban vulnerability and supporting informed decision-making.

Keywords: GIS, spatial-temporal vulnerability, vulnerability map, vulnerability scale.

PREDICTION OF MOMENT CAPACITY OF FLUSH END PLATE CONNECTION: A MACHINE LEARNING APPROACH

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Abstract. This study focuses on the importance of flush end plate connections in steel structures and the potential for failure if bolts are damaged, leading to shear, bending, or fatigue failure. To avoid failure, it is critical to predict the connection's moment capacity against anticipated loads and design criteria. Simulated results from experiments and numerical simulations were compared with actual results. Current finite element models and experiments have shown limitations in making accurate predictions. This paper developed improved machine learning techniques to accurately forecast moment capacity, using various parameters such as bolt diameter, end plate width, and nominal yield stress. To create our models, a wide range of works with data spanning 25 years were examined. The analysis illustrated that among all the ML models that were examined in this study, the Xtreme Gradient Boosting (xgBoost) model demonstrated the best prediction performance which is also confirmed by comparing its predictions with those of the existing models. This study highlights the potential of machine learning techniques in accurately predicting the moment capacity of flush end plate connections.

Keywords: Structeral steel, flush end plate, connection, flange, machine learning, moment capacity.

EXTENDED REALITY IN CIVIL INFRASTRUCTURE: A COMPREHENSIVE REVIEW

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Abstract. Extended Reality (XR) integrates Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), enabling users to interact with virtual objects and environments as if they were real. XR has found widespread use in civil infrastructure, including design, visualization, worker training, remote collaboration, and maintenance. This paper provides a comprehensive review of the impact of XR on Civil Engineering and highlights its benefits for design and infrastructure. We conducted our review using articles from conferences and journals. Our review identifies the distribution of XR technology in civil infrastructure, design strategies employed in creating digital technology, and their limitations. Furthermore, our review lays the groundwork for developing the best practices for XR technology in civil infrastructure and suggests future research agendas.

SIMPLIFIED SOLUTION FOR THIN PLATES RESPONSES USING BEAMS THEORY WITH REPETITIVE BOUNDARY CONDITIONS

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Abstract. In this study, a semi-analytical method is suggested for the analysis of thin plates. Various methods such as superposition, finite element, and integral transform have been applied to obtain solutions for thin plates. In this study, a simplified method has been proposed through an extension from the classical beam theory has been proposed to solve plates, which is easier to apply yet relatively accurate. The method uses shape functions obtained from beam solutions having similar boundary conditions. The shape functions are used to approximate the displacement profile of the plate. Galerkin's method is then applied to obtain the analytical solution of plate deflection. This involves evaluating integrals, which must be computed only once and the values can be used later. The proposed moment and deflection coefficients are compared with that available in the literature. The results have been compared with previously reported solutions. The maximum error in the case of displacement of a simply supported plate was found to be 1.35% only. The shape functions and the values of integrals corresponding to various boundary conditions have been presented. Plates of various sizes and having various boundary conditions may be analyzed using the proposed closed-form solution for moment and shear. In addition, accurate deflection measurement of thin plates by other methods can be difficult and time-consuming. Therefore, this study explored analytical solutions that may provide a relatively accurate solution for thin plates with comparatively less computational effort.

FRAGILITY ANALYSIS OF ANCHORAGE CONNECTION OF CIRCUIT BREAKER IN SWITCHYARDS

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Abstract. The study being conducted here is of great significance, as it aims to evaluate the fragility of anchorage connection of electrical equipment items in switchyard, which can help support the seismic design. Given that the risk of seismic damage during ground motion is a serious concern, it is imperative to have a reliable and accurate method to assess this risk. This is where the developed fragility curve comes in, which is a valuable tool to determine the probability of damage occurring during seismic events. The methodology used to develop this curve is based on the design standards of FEMA 450, FEMA 451, and ACI 318, which are widely recognized and respected guidelines in the industry. With this information, it is possible to design and implement measures to mitigate the risks of damage to electrical equipment items in switchyards, and ultimately help ensure the safety and reliability of these critical systems. Overall, this study is a vital step towards improving our understanding of the fragility of electrical equipment items in switchyards and addressing the risks associated with seismic events.

Keywords: Fragility Curve, Electrical Equipment item, Switchyard, Probabilistic Risk Assessment.

REVIEW OF NATIONAL BUILDING CODE DESIGN PROVISIONS, RETROFIT AND SAFETY GUIDELINES FOR NUCLEAR POWER PLANT (NPP) ZONE IN BANGLADESH

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Abstract. The Bangladesh National Building Code (BNBC) is a pivotal document that provides guidelines for safe and efficient construction in Bangladesh. However, with the growing need for energy, nuclear power plants (NPP) are becoming increasingly prevalent in the country. Therefore, there is a need for specific design provisions, safety guidelines, and retrofit measures for buildings located in the NPP zone to ensure their safety and security. This paper presents a comprehensive review and analysis of the BNBC's design provisions, safety guidelines, and retrofit measures for buildings in the NPP zone. The study identifies the strengths and weaknesses of the current BNBC provisions and proposes recommendations for improvement. The review of the design provisions covers various aspects, especially seismic design. Similarly, the safety guidelines cover various topics such as emergency planning, radiation protection, and security measures. The retrofit guidelines consider both the structural and non-structural retrofitting of existing buildings to ensure their safety in the unexpected event of an NPP accident. The study finds that the current BNBC provisions provide a good foundation for building design and safety but they do not adequately address the unique challenges of buildings in NPP zone. The study recommends that specific provisions be developed for buildings in the NPP zone, including more stringent requirements for structural seismic design, safety, and emergency planning. The study also recommends the development of more detailed retrofit guidelines for existing buildings in the NPP zone. Overall, the study highlights the importance of ensuring the safety and security of buildings in the NPP zone in Bangladesh and provides valuable insights into the design provisions, safety guidelines, and retrofit measures required for achieving this goal.

Keywords: Bangladesh national building code (BNBC), nuclear power plant (NPP), seismic design, safety guidelines, retrofit guidelines.

STUDY OF MULTI-STORIED BUILDINGS IN ETABS USING STATIC AND DYNAMIC ANALYSIS FOR DIFFERENT SEISMIC ZONES IN BANGLADESH

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Abstract. Structural response against seismic actions has been a prime issue nowadays. It is quite a dominant parameter while various infrastructures are growing vastly, specifically in the higher seismic-prone areas. While stiffness, mass, and some other characteristics influence a structure's dynamic behavior, rigidity characteristics alone determine a structure's motionless behavior. In such cases, static as well as dynamic response analysis of multi-storied structures is necessary to ensure overall structural stability and efficiency. Likewise, according to the Bangladesh National Building Code (BNBC-2020), the current study's goal is to evaluate how multi-story structures behave in terms of story displacement, story drift, base shear, and torsional irregularity. This study examined G+10 and G+20 narrative structures in different zones of Bangladesh. The buildings were modeled using ETABS-2016 (Extended Three-Dimensional Analysis of Building System). On the modeled structures, linear static and linear dynamic analyses were conducted. Static analysis was performed using the Equivalent Static Method and dynamic analysis was executed using Response Spectrum Analysis. The results show that structures in areas with higher seismic zone coefficients are more vulnerable to seismic actions. This is rational in both static and dynamic analysis. This study aims to illustrate the variations in outcomes and demonstrate Response Spectrum Analysis's supremacy over Equivalent Static Analysis for high-rise buildings.

Keywords: ETABS, response spectrum analysis, equivalent static method, multi-storied, BNBC-2020, and story displacement.

FINITE ELEMENT ANALYSIS OF PUSH-OUT TEST FOR REBAR SHEAR CONNECTORS

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Abstract. Steel-concrete composite beams have been widely acknowledged as a highly cost-effective structural solution for multi-story steel buildings and steel bridges. This paper investigates the behaviour of rebar shear connector embedded in solid concrete slab in composite floor system. A nonlinear 3D finite element model was developed to simulate the push-out test on rebar shear connector which is a standard test used to determine the shear behaviour of connectors used in composite construction. The shear strength capacity of rebar shear connector obtained from the numerical analysis was compared with the experimental results. A total of eleven push-out test specimens were modeled. The mean value of P_{FEM}/P_{EXP} was found to be 1.0 with a standard deviation of 0.12. The finite element model was also able to simulate experimental failure behaviour of rebar connectors in push-out tests. The simulation models incorporating smaller diameter connectors (10 mm and 12 mm) exhibited failure primarily due to shearing of the rebar connectors. In contrast, the failure of models featuring 16 mm and 20 mm diameter rebar connectors was initiated by concrete cracking. subsequently leading to either concrete crushing or connector shearing. The numerical model was also capable of predicting the effect of rebar diameter and concrete strength in shear capacity of rebar connectors as observed in the push-out experiment. The model confirmed that shear resistance increases with larger diameter rebar and higher concrete strength.

Keywords: Shear connector, concrete, steel, composite, push-out, numerical, ultimate capacity.

SEISMIC PERFORMANCE ANALYSES OF HIGH-RISE STRUCTURES CONSTRUCTED WITH POLYVINYL ALCOHOL (PVA) FIBERED ENGINEERED CEMENTITIOUS COMPOSITE (ECC) IN BANGLADESH: CASE STUDY

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Abstract. The seismic performance of high-rise structures is critical to ensure the safety and structural integrity of buildings in earthquake-prone regions. Engineered Cementitious Composites (ECC) have emerged as promising construction material due to their unique mechanical properties, such as high ductility, strain-hardening behavior, and enhanced energy dissipation capabilities. The addition of Polyvinyl Alcohol (PVA) fibers further enhances the tensile and flexural properties of ECC, making it an attractive option for seismic-resistant structures. This research paper presents a comprehensive study on the seismic performance analyses of high-rise structures constructed with PVA fibered ECC over conventional reinforced concrete (RC) structures. This study aims to evaluate the effectiveness of PVA-fibered ECC in enhancing the seismic performance of tall buildings under different seismic loading conditions and the variation of PVA fiber and steel rebar percent. A parametric study series is performed using advanced finite element method (FEM) analysis techniques. The high-rise structures with PVA fibered ECC are subjected to El Centro ground motion records representing different seismic hazard levels analyzed through time history direct integration method considering material nonlinearity and P-delta effect. The response of the structures, including displacements, accelerations, inter-story drifts, and stress distributions, are thoroughly examined and compared with conventional concrete structures. The results of the analyses demonstrate the superior seismic performance of high-rise structures constructed with PVA fibered ECC compared to conventional concrete structures. The PVA-fibered ECC exhibits enhanced ductility and energy dissipation capacity, effectively reducing the seismic demands on the structural elements.

Keywords: ECC, seismic analyses, PVA, FEM, nonlinearity, ductility, energy dissipation.

EFFECT OF RE-ENTERING SHAPE MEMORY ALLOY DAMPER ON SEISMIC RESPONSE OF TORSIONALLY COUPLED IDEALIZED FRAME SYSTEM

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Abstract. The torsionally coupled buildings are more vulnerable during strong earthquake ground motions. When a shape memory alloy (SMA) damper is used, the response of structures to lateral and torsional motion is effectively reduced. In this research, numerical investigation is carried out on the seismic response of an idealized single-storey asymmetrical frame system with a SMA damper subjected to strong earthquake ground motions. SMA damper restoring force, eccentricity ratio and lateral and torsional displacements are all variables in this parametric study. The SMA damper-controlled frame's reaction is measured compared to that of the uncontrolled frame. It is found that the implementation of the SMA damper results in significant reduction in the seismic response of the structure.

Keywords: Earthquake, shape memory alloy, re-centering, asymmetric structure

EARTHQUAKE VIBRATION ATTENUATION OF THE BUILDING STRUCTURE USING FLOATING SAND FILL BALLS IN TUNED LIQUID COLUMN DAMPER

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Abstract. The study focuses on the reduction of the earthquake-induced vibration of the building structure by using Modified Tuned Liquid Column Damper. The modification of the Tuned Liquid Column Damper or TLCD is done by employing sand-filled floating balls in association with the liquid inside. The sand-filled floating balls act as a barrier against the free sloshing of the liquid and dissipate the kinetic energy by creating a turbulent damping force. The dissipation considerably reduces the displacement at the top of the building structure. An experimental three-storied structure of steel is utilized as a multi-degree-of-freedom system structure (MDOF) to perform the earthquake shake table experiment. The ground and top displacement data of the structure excluding and including the damper are referred to as uncontrolled and controlled data respectively. This investigation is carried out considering the time (s), liquid height (inches), free and fixed floating of the sand-filled balls, and the percent weight of sand (g.) used in the hollow core of the balls. The cases for the increased percent weight of sand in balls and liquid heights are compared to all the parameters and the conventional TLCD. The comparisons between the uncontrolled and controlled data show that the displacements (mm) reduce due to the application of the sand-filled floating balls in TLCD. Optimal percent weights of sand-filled balls and optimal water level heights for the experimental time (s) of shaking are presented here for which the displacements decrease the most. From the findings, it is evident that modifying the Tuned Liquid Column Damper by adding sand-filled floating balls is more robust than the conventional TLCD.

Keywords: Tuned liquid Column Sand Ball Damper, multi-degree of freedom, earthquake shake table, water sloshing, sand-filled floating ball

PERFORMANCE EVALUATION OF DEFAULT NONLINEAR HINGES OF ETABS TO PREDICT LATERAL BEHAVIOR OF RC FRAME

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Abstract. Bangladesh is located in an earthquake prone region where many multi-storied buildings have already been constructed to satisfy the ever-increasing demand. However, several buildings are seismically vulnerable because of design inadequacies and poor construction practices. Bangladesh National Building Code (BNBC) suggests an equivalent static method to design new buildings for earthquake. However, the performance of existing RC buildings under seismic events should be evaluated by nonlinear static or dynamic analysis based on the buildings' characteristics. Nonlinear static analysis, also known as pushover analysis, can predict the overall lateral behavior of a building and the damage extent of structural members under seismic loads. Pushover analysis can be conducted using different commercial software, e.g., ETABS, considering lumped plasticity models of nonlinear hinges. In ETABS, nonlinear hinges can be modeled using default or user-defined properties. Default hinge properties follow ASCE 41-13 guideline, whereas user-defined hinges need a computed moment-curvature relationship of beam or column. In this regard, the performance of default hinge properties to predict lateral behavior and damages of the building is required to be verified with the experimental behavior of the RC frame. In this study, two single-story and single-bay RC bare frames, available in literature, have been modeled using default nonlinear hinge properties as per ASCE 41-13 guideline by ETABS 2016. The numerical analysis results, i.e., lateral behavior of bare RC frames have been compared with experimental behavior with a fair agreement.

Keywords: Evaluation, hinge, RC frame, pushover, ETABS.

INVESTIGATION ON THE IMPACT OF BRACINGS AND SHEAR WALLS ON SEISMIC PERFORMANCE OF BUILDINGS

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Abstract. Earthquakes result in severe damage to buildings and infrastructure, as well as loss of life and displacement of communities. One of the most crucial ideas in structural engineering is the construction of earthquake-resistant structures to mitigate the effect of seismic movements on the structure. According to Bangladesh National Building Code 2020 (seismic criteria as per ASCE 7-05), there are four seismic zones (I, II, III, IV) where the intensity of earthquake could be higher in seismic zones with higher coefficients. Due to their straightforward construction techniques and simplicity of installation, bracing, and shear wall are typically employed to create earthquake-proof structures. These two systems significantly contribute to the stiffness of the building. The study aims to be beneficial for structural engineers to choose a suitable configuration for building design according to the architectural and functional requirements. With the help of the CSi ETABS program, a G+15 building is modeled in zone no two in Bangladesh. For the current study, response spectrum analysis is used to conduct the analysis. Different parameters such as storey drift, storey shear, and fundamental period were compared for building models equipped with steel bracings and shear wall approaches. The outcome of the research shows that both the steel bracing as well as shear wall method is effective to resist lateral deflection.

Keywords: Bracing, shear wall, response spectrum analysis, storey drift, storey displacement, ETABS.

SEISMIC PERFORMANCE OF REINFORCED CONCRETE (RC) FRAME STRUCTURE WITH HAUNCH BEAMS

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Abstract. The provision of a haunch in beams reduces self-weight, increases shear capacity at support, and enhances joint performance. The present study investigates the seismic performance of reinforced concrete (RC) framed buildings with different numbers of floors: six, nine, twelve, and fifteen floors with haunched beams. Twelve nonlinear static analyses have been conducted to predict seismic performances. Plastic hinges are provided with two ends and a central point of beams, and two ends of columns. The characteristic of plastic hinges of beams and columns controls major axis bending and bi-axial bending with axial compression, respectively. Beams and columns have been considered 2-nodded line elements for the finite element formulations. In most cases, ground floor columns reached the life safety level for the fifteen-storied structure under earthquake excitation compared to RC buildings with a smaller number of floors. In addition, almost 80% of the ground floor beams of the 15-storied structure are reached the collapsed prevention performance level. Furthermore, the present numerical code used in this study has been validated with the identical model building of previously published work. The difference in results has been found to be (4~5) %, which ensures accuracy and better performance of the present study to enhance this research in the future.

Keywords: Finite element method, Frame structure, Haunch beam, Nonlinear, Reinforced concrete, Seismic performance.

VIBRATION-BASED DAMAGE IDENTIFICATION OF A STEEL FRAME USING AN OUTPUT-ONLY ALGORITHM

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Abstract. There are various approaches used by different research groups to identify structures and structural changes, and the success of a certain methodology may depend on the context in which it is applied. Therefore, it is crucial to verify promising methodologies by testing them on different structures and damage cases. The objective of this study is to investigate a statistical pattern recognition based method of Structural Health Monitoring (SHM) using a laboratory structure. Sophisticated finite element models and traditional modal parameters are not used in the implementation of the statistical pattern recognition techniques, as they require significant user interaction. Instead, the statistical approaches presented in this paper is solely based on the signal analysis of the measured vibration data. This makes this approach attractive for the development of an automated health monitoring system. A large-scale laboratory structure was constructed at the Qatar University structures laboratory, and a large dataset of vibration signals was obtained under several structural damage scenarios. This paper suggests a statistical moments based technique to identify damage using the vibration signals. The method does not require labor-intensive supervised learning, and only acceleration sensor data is required to detect damage. Overall, the proposed approach has the potential to be a cost-effective and efficient solution for SHM of various infrastructures.

Keywords: Structural health monitoring, statistical pattern recognition, vibration signals, laboratory structures, damage identification, automated system, statistical moment analysis.

EFFECT OF LRB CONSTITUTIVE MODELS ON THE SEISMIC RESPONSE OF AN LRB-ISOLATED HIGHWAY BRIDGE

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Abstract. Seismic isolation devices are widely used to improve the seismic performance of bridges by mitigating the expected damage. Lead rubber bearing (LRB) is a commonly utilized seismic isolation system, and numerous analytical models of LRB have been proposed in the literature. However, each model has its unique benefits and drawbacks. The aim of this research is to investigate the seismic performance of an LRB-isolated bridge considering different LRB modeling techniques. For this purpose, an LRB-isolated three-span curved steel girder bridge is considered as the reference bridge which was tested in a shake table at the University of Nevada, Reno. Initially, a validated numerical model of the reference bridge is developed using OpenSees. Four different LRB modeling techniques, namely ElastomericX, LeadRubberX, KikuchiAikenLRB, and a new LRB modeling technique, are then utilized to model the isolation bearings. The new LRB model is developed as a part of this study which has been validated against available experimental results. The seismic response of the isolated bridges are evaluated in terms of isolator force-deformation relationship, bearing shear strain, energy dissipation capacity, and pier shear force. 22 far-field ground motions compatible with the bridge site location have been used to compare the performance of the proposed LRB model with existing LRB models. The comparative analysis reveals that the modeling techniques have a significant impact on the seismic assessment of LRB-isolated bridges. Also, the new LRB analytical model can accurately predict the nonlinear behavior of LRB and subsequently make the seismic assessment of LRB-isolated bridges more accurate.

Keywords: Lead rubber bearing, Fragility analysis, Seismic performance, Base-isolated bridge.

REVIEW ON THE INFLUENCE OF DIFFERENT TYPES OF FIBERS ON BEAM-COLUMN JOINT UNDER CYCLIC LOADING

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Abstract. The joint between a beam and a column is the most vulnerable structure component to collapse during an earthquake. One of the approaches to strengthen the beam-column joint is the application of fibers. A structure's tension and compression load carrying capability determines its susceptibility to seismic loads. The use of fiber is known to enhance concrete's mechanical, flexural, and durability properties for its high tensile strength. Steel fiber, glass fiber, polypropylene (PP) fiber, basalt fiber, etc., and different hybrid fibers are currently being studied to understand their functionality to improve the maximum load, failure pattern, stiffness, hysteretic response, and energy absorption capacity of the beam-column joint when subjected to cyclic loading. This study reviews the influence of fiber volume and their optimum aspect ratio in upgrading these properties through a literature review. Steel fiber has better bridging of wider cracks, and PP fiber limits the micro-cracks; hence their hybrid form significantly increases the strength and ductility by controlling both macro and micro-cracks. Carbon and PP fiber are observed to increase the energy dissipation capacity better than other fibers. This review paper outlines that incorporating different fibers can be suitable for strengthening beam-column joints considering engineering properties and economy.

Keywords: Cyclic Load, Beam-Column Joint, Fiber, Displacement, Stiffness, Energy Dissipation.

PROGRESSIVE COLLAPSE OF MULTI-STORY FRAME STRUCTURE UNDER COLUMN LOSS SCENARIOS

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Abstract. Progressive collapse is the result of a failure of structural components that affect the entire structure, ultimately causing the global collapse of the structure or its significant proportion. The sudden removal of the column increases the bending moment and shear force at the surrounding frames significantly. In this case study, a 7-story frame structure has been investigated under accidental column loss using Finite Element (FE) method. In addition to regular loadings, the dynamic load is applied as a time function to simulate the column loss scenario and collapse progression. In the analysis process, one, two, or three-column loss scenarios are analyzed to understand dynamic load redistribution and their effect on the global structure. As key parameters of the structure, maximum story drift, displacement, inter-story drift, story shear, base shear, and overturning moments are presented with the time. It is important to note that the building started its permanent deformation after 10 seconds, approximately. The research found that the vulnerability of the structure escalated as more columns were removed. The affected loading area linked to collapse vulnerability determines the amount of energy the building needed to absorb. The response of the structure also suggested that the damping properties of the structure are also playing a key role in the process of delaying the global collapse of the structure.

Keywords: Progressive collapse, column loss, finite element model, time history analysis, Damping.

SIGNIFICANCE OF SHEAR WALLS ON NONLINEAR BEHAVIOR AND SEISMIC PERFORMANCE OF REINFORCED CONCRETE FLAT-PLATE BUILDINGS

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Abstract. These days, designers are favoring space-efficient and economical constructions. Flat plate system saves space since it transfers gravity loads directly to the column without a beam. Yet, lateral seismic load and punching failure due to unbalanced moments are major concern for flat plate structures. To overcome these limitations, concrete shear wall has been introduced with flat plate structures. In this study nonlinear behaviour and seismic performance of flat plate-shear wall (SW-FP) structural system has been investigated. Also calculate seismic parameters for SW-FP structural system through Nonlinear Static Analysis. Here, 5 (Five) models has been developed with varrying the location and proportion of shear wall. Design the model according to BNBC 2020 loads for moderate seismic zone (Zone-2) and conducted pushover analysis according to ASCE 41-13 Displacement Coefficient Method. Comparing displacement from pushover curve it is observed that displacement reduces significantly and shear walls aslo have notable effect on seismic design parameters. Seismic parameters found from this study can be used further for designing SW-FP structures in future. According to the analysis, shear walls significantly boost the performance under nonlinear static loading and enhance their performance under strong earthquake loads.

Keywords: Flat plate, shear wall, lateral load, seismic parameter, earthquake, response modification factor.

EFFECT OF TRANSVERSE REINFORCEMENT ON THE SEISMIC DESIGN OF BRIDGE SUBSTRUCTURE IN HIGH SEISMIC ZONE OF BANGLADESH

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Abstract. The seismic performance study of bridges is critical for any earthquake-prone areas all over the world. The performance-based seismic design of bridge substructures in high seismic zones of an earthquake-prone country like Bangladesh is an important research topic due to the potential impact of earthquakes on the country's transportation infrastructure. As Bangladesh has no bridge code, bridge designers in our country follow the AASHTO code to design bridges. The purpose of this research is to assess the seismic performance of a constructed bridge in a higher seismic zone of Bangladesh using the AASHTO guideline and the BNBC-defined seismic response spectrum for different tie spacing under different levels of the earthquake. This paper presents the result of the numerical models of the bridges that were designed according to the force-based method for high seismic zone i.e., Sylhet. The only variable considered in this study is the spacing of transverse reinforcement. The results demonstrate that hinge capacity increases with the decrease of tie spacing. Furthermore, an increase in transverse reinforcement led to a significant improvement in ductility.

Keywords: Bridge, AASHTO, BNBC, earthquake, performance-based design, transverse reinforcement.

SEISMIC PERFORMANCE ASSESSMENT OF FLAT SLABS IN BUILDINGS WITH SHEAR WALLS

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Abstract. This paper presents a study on the seismic performance of reinforced concrete shear wall-flat plate (SW-FP) structural systems. The study involves three types of variations of parameters: with varying numbers of bays in the y-direction (Type B), in the x-direction (Type C), and with different slab thicknesses. The slabs are modeled using two types of elements: layered shell elements and thick shell elements. The seismic performance of the models was studied using the Nonlinear Static Analysis (NLSA) procedure. The acceptance criteria for slab-column connections provided in ASCE 41-17 are used to assess the global performance of slabs in terms of rotation. The slab plastıc rotations for all 36 models are calculated for Maximum Considered Earthquake (MCE), Design Basis Earthquake (DBE), and Serviceability Earthquake (SE) levels, using target displacement obtained by pushover analysis in ETABS. The results show that all models perform within the immediate occupancy limit for the SE level; for DBE and MCE levels, the models perform within either the immediate occupancy or life safety limit. The study reveals that the layered shell models demonstrate less rotation angle and a higher performance level than the thick shell models. An increase in slab thickness reduces the plastic rotation, and the models with the lowest aspect ratio exhibit the lowest slab rotation. The difference in results that are obtained from simulating the slab using different shell elements can be utilized to provide valuable guidance for the design of similar structures in the future.

Keywords: Layered shell, thick shell, plastic rotation. MCE, DBE, SE.

A MULTI-OBJECTIVE GLOBAL OPTIMIZATION APPROACH FOR VIBRATION AND COST MINIMIZATION OF A REINFORCED CONCRETE TALL BUILDING

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Abstract. In earthquake-prone areas, designing tall buildings that can withstand the ground vibrations caused by seismic activity is crucial. One approach to mitigating these vibrations is through the use of Tuned Mass Dampers (TMDs). This paper presents a multi-objective optimization approach using the NLopt algorithm to design TMDs. The optimization is performed by optimizing the parameters of the TMD located at the roof of different building configurations, with the objective functions of cost and maximum top displacement minimized under two earthquake ground vibration. To support the optimization process, a computer program has been developed in C++ linked with the algorithm. Obtained results show that NLopt is effective in optimizing structural performance with a significant reduction in sway and the choice of better TMD parameters under seismic activity. The findings of this study can provide a useful guideline for designers and engineers to optimize TMD parameters and improve the structural performance of tall buildings in a cost-effective manner under seismic activity.

Keywords: Tuned mass dampers, multi-objective optimization, structural safety, earthquake ground vibration, computer program development, tall buildings.

ANALYSIS OF SEISMIC DAMAGE PATTERNS OF A CROSS-FAULT SIMPLY-SUPPORTED ISOLATION GIRDER BRIDGE

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Abstract. Compared with non-fault-crossing bridges, fault-crossing bridges shall experience relative dislocation on two sides of a fault in addition to dynamic responses. The damage pattern due to such effect can thus be different. A simply-supported isolation girder bridge is simulated and analyzed in consideration of an ideal strike-slip fault. The pounding effect between adjacent girders and between girders and abutment are analyzed. It is found that the relative displacements on two sides of a fault may increase the longitudinal deformation of the isolation bearings. The cross-fault girder shall exhibit in-plane rotating movement. The findings are in accordance with existing laboratory experiments as well as collected bridge damage information from past earthquakes.

Keywords: Cross-fault, isolation girder bridge, seismic analysis, strike-slip, pounding effect.

FINITE ELEMENT ANALYSIS OF CYCLIC BEHAVIOR OF STEEL SHEAR LINKS OF DIFFERENT MATERIALS

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Abstract. Shear link is a small beam like segment used as a structural fuse which dissipates seismic energy primarily through shear deformation in seismic resilient structural systems like eccentrically braced frames and coupled shear wall systems. Previous studies have focused mainly on mild steel link specimens, but behavior of links of other effective energy dissipating materials such as stainless steel and low yield point steel could be further explored. This paper aims to understand the cyclic behavior of stainless steel shear links under cyclic loading conditions and compare the results with those obtained for mild steel links. For this purpose, Finite Element Model of shear link using ANSYS has been developed and validated with previous experimental results. In addition to this, a Finite Element Model of a flat coupon specimen of stainless steel has also been developed. The plastic hardening parameters were fitted with the experimental results and the coupon model was validated. After validation, the plastic hardening parameters validated were used in previously validated shear link models to generate shear links of stainless steel. Cyclic loading was applied according to experimental studies and comparative studies on energy dissipation capacity for stainless steel and mild steel models was done. From the results, it was found that shear link of stainless steel significantly outperformed its mild steel specimen in terms of energy dissipation capacity. Thus, making stainless steel a more efficient material to be used in shear links in seismic resilient structural systems like Eccentrically Braced Frame, Coupled Shear Wall, etc.

Keywords: Shear Link, Stainless Steel, Cyclic load, Energy Dissipation, Finite Element analysis

PLASTIC HINGE LENGTH IN REINFORCED CONCRETE COUPLE SHEAR WALL BUILDINGS FOR SEISMIC REINFORCEMENT DETAILING – A COMPARISON STUDY

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Abstract. Proper reinforcement detailing in plastic hinge regions is one of the important measures that could help damage control of structural walls subjected to any severe earthquake event. Inelastic curvatures are commonly assumed to be uniform over a height called plastic hinge length. Non-linear dynamic analyses are performed on a set of coupled shear wall buildings of simple configurations for different heights. Inelastic curvatures are calculated on numerous heights of all the buildings and plotted along with the height of the buildings. Plastic hinge lengths are estimated with the yield curvatures from analytical results. It becomes a common practice to estimate the plastic hinge length equal to 0.5 to 1.0 times the wall length, which basically were developed from experimental studies on beam and column elements. As per the Canadian standards CSA A23.3-04, the requirements to calculate plastic hinge lengths are identical for both cantilever and coupled shear walls, i.e., 1.5 times the wall length in the direction under consideration. Results from the present study shows that inelastic curvatures are not uniform over the plastic hinge length and the Canadian requirement to calculate plastic hinge length is unconservative as per CSA A23.3-04 and overconservative as per CSA A23.3-14 for couple shear walls and more critical for slender coupled shear walls. A brief comparison also has been made between Canadian standard (CSA A23.3-04/14) and Bangladesh National Building Code (BNBC-2020). A new multiplication factor is proposed for the safe estimation of plastic hinge length for couple shear walls of medium and high rise reinforced concrete buildings.

Keywords: Reinforced Concrete, Buildings, Couple Shear wall, Non-linear Dynamic analysis, Plastic Hinge, Seismic design, Inelastic Curvatures, Damage control.

ASSESSING RISK PERCEPTION AND ENHANCING EARTHQUAKE AWARENESS: A CASE STUDY OF DHAKA

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Abstract. This case study aims to assess the risk perception of earthquakes among the residents of Dhaka, the capital city of Bangladesh, and explore strategies to enhance earthquake awareness. This research intends to shed light on the current condition of risk perception and readiness levels in Dhaka, a location prone to seismic risks, by performing a comprehensive examination. To provide a representative sample of the population, a questionnaire was devised to collect data using home and sidewalk surveys. The purpose of this study is to look at the effects of gender, education level, and casualty knowledge on attitudes, perceptions, and behaviors linked to seismic risks and earthquake preparedness among Dhaka, Bangladesh citizens. According to the data analysis, female respondents have a higher risk perception and better earthquake preparedness than male respondents. Furthermore, when compared to older people, younger people have a better understanding of earthquake preparedness. Moreover, participants with a higher degree of education demonstrate a better level of preparation. The study emphasizes the lack of public awareness of seismic risk and the need to increase public understanding of earthquake theory and emergency response. The findings emphasize the importance of targeted risk-mitigation training programs and interventions in improving risk perception and encouraging effective risk-mitigation methods. Addressing these gaps will allow policymakers and stakeholders to work together to improve Dhaka's resilience and readiness in the face of seismic hazards.

Keywords: Seismic risk perception, earthquake preparedness, public awareness, risk-mitigation strategies, gender difference, stakeholders.

RELIABILITY ANALYSIS OF REINFORCED CONCRETE BUILDING SUBJECTED TO SEISMIC LOADS: MATERIAL UNCERTAINTY

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Abstract. As part of this work, the reliability analysis of the seismic performance evaluation of reinforced concrete buildings was investigated, taking the uncertainties related to the resistance of the materials into consideration. The response surface methodology (RSM) was used to develop an explicit representation of the failure function. The overall displacement of the building's roof is used to define the limit state. Using FE software ABAQUS (2014), finite element (FE) computations were used to analyze the building's seismic performance. The fluctuations in concrete's compressive strength, as well as the strength and modulus of elasticity of the reinforcement steel, were represented by three random variables. The dynamic time history analysis of a 3-story RC building modeled in ETABS with real earthquake data collected from Bangladesh was performed on a total of 27 combinations over the domain of random variables using ABAQUS (2014). Combining the FE findings obtained from 27 permutations, a multiple polynomial regression analysis was developed to create the building response surface model in terms of roof displacement. The permitted roof displacement recommended by BNBC (2020) and the actual roof displacement generated through regression analysis were combined to generate the serviceability limit state function. Monte Carlo Simulation and First order reliability techniques (FORM) were applied to conduct a reliability study using MATLAB. There was discovered to be a sizable disparity between FORM and MCS. With good accuracy, the MCS reliability approach can be employed on a surface response model.

Keywords: Seismic reliability, Structural reliability, Response Surface Model, Multiple Regression analysis, MCS, FORM.

COST-EFFICIENT IOT APPROACH FOR REMOTELY MONITORING CONSTRUCTION SITE ENVIRONMENT AND MACHINE RUNTIME TO MITIGATING FALSE FUEL CONSUMPTION REPORTING

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Abstract. Efficient coordination and management are essential for successful construction projects with minimal financial losses. This paper proposes a low-cost and portable system that uses the ESP8232 module and affordable sensors to remotely monitor construction machinery. The system features offline data storage capability and automated logging using Google Sheets. It offers a cost-effective and portable solution to improve the management and monitoring of construction sites, highlighting the potential to enhance construction site management. The proposed system can help construction firms manage their sites more efficiently, leading to higher-quality projects and reduced financial losses.

Keywords: IoT, Remote Monitoring, Wireless Data Logging, Environment Monitoring

AXIAL BEHAVIOR OF NEW BRICK AND RECYCLED BRICK AGGREGATE CONCRETE COLUMNS

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Abstract. Most old structures in Bangladesh are made of poor-quality materials, low-strength concrete (about 15-25 MPa strength), and brick aggregate because of the acute scarcity of natural stones in the early days. The adequacy of these old structures remains a question. Moreover, the updated building code demands a more stringent design philosophy. Therefore, this research aims to investigate the axial behavior of such old columns under concentric loading. The columns are prepared with recycled brick aggregate concrete (RBAC) and compared with new brick aggregate concrete (NBAC) columns. Two concrete strengths are designed using recycled brick aggregate (RBA), such as 17 MPa and 25 MPa, whereas only 17 MPa concrete is prepared using new brick aggregate (NBA) for comparison purposes. Five square columns of one-third scale with dimensions of 150 mm × 150 mm × 950 mm are tested under concentric loading to investigate the behavior of sub-standard brick aggregate concrete columns regarding failure mode, axial capacity, deformation response, ductility, and toughness. The results show that the axial capacity of the 17 MPA NBAC and RBAC columns is similar, but increasing the strength of RBAC columns from 17 MPa to 25 MPa increases up to 32% capacity. Thus, this study will also encourage engineers to reuse recycled brick aggregate (RBA) in reinforced concrete (RC) members by ensuring proper structural detailing.

Keywords: Brick aggregate, recycled aggregate, low-strength concrete, axial capacity, ductility, toughness.

IDENTIFICATION OF FRP DEBONDING OF AN I-GIRDER BRIDGE USING STATISTICAL ANALYSIS OF IMPULSE INDUCED VIBRATION RESPONSES

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Abstract. In aging civil structures, applying fiber-reinforced polymer (FRP) for retrofitting has been found to be effective. However, debonding of it from the structure may lead to catastrophic failure. Some identification methods for FRP debonding locations have been researched recently. In this paper, the method described uses a non-model-based, unsupervised, output-only method using statistical analysis. Here, only FRP debonding or damage location was investigated; severity was not measured. 3D Finite element modeling of an FRP-bonded I-girder bridge is performed in Abaqus. The damage situation has been simulated by the debonding of FRP. The excitation is an impulse load, and consecutive structural responses are collected at specified sensor-mounted points along the bridge span in flaw-induced damaged and undamaged conditions. A second-order statistical moment has been calculated for both sets of data (damaged and undamaged) in the frequency domain. The differences between the statistical moments of the responses of these damaged and undamaged conditions are calculated. The curvatures of these statistical moment differences (CSMD) are calculated and plotted against the sensor position. From the plotted curve, the FRP debonding location has been identified. Different responses' (displacement, velocity, acceleration, and strain) performance to identify FRP debonding location have also been studied.

Keywords: Impulse load, FRP debonding, sensors, strain responses, statistical method.

SELF HEALING CONCRETE: A REVIEW

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Abstract. Self-healing concrete is a promising technology that has the potential to enhance the durability and sustainability of concrete structures. This analysis provides an overview of various self-healing mechanisms and their effectiveness, highlighting strengths and limitations. One of the most promising methods for concrete repair is using bacteria that produce calcium carbonate, but other types of bacteria may also be used for different self-healing mechanisms. Encapsulated healing agents have also been used as a chemical reaction to repair cracks in concrete, but implementing them in the field presents difficulties, such as the need for precise control over the release of agents. These methods are still in the early stages of development and require further study before widespread implementation. Challenges to implementing self-healing concrete include cost, scalability, and the need for continued monitoring and maintenance. Overall, self-healing concrete has the potential to revolutionize the construction industry, but there is still much work to be done to overcome these challenges and ensure its widespread adoption. This review provides significant insights for construction industry professionals, researchers, and policymakers regarding the potential of self-healing concrete and its implementation challenges.

Keywords: Microbial concrete, durability, sustainability, hydrogels, encapsulation, influencing factors.

THERMAL ANALYSIS OF CONCRETE BOX-GIRDER BRIDGE EXPOSED TO INTERIOR FIRE USING SAFIR

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Abstract. Box girder is a widely used bridge system and, consequently, quite common in Bangladesh. The structural capacity of such box girders can be significantly affected during fire exposure due to their thin webs and prestressing tendons. In this study, the thermal behavior of box girder sections exposed to both standard and hydrocarbon fire within the interior hollow part has been investigated using the non-linear FEM software SAFIR. The standard fire has been used to simulate any accidental fire that could occur during the construction or operation phase of a box girder structure. On the other hand, hydrocarbon fire has been applied to simulate an explosion of gas pipelines that could run through the interior of a box girder section. A parametric study has been conducted with varying web thickness and fire duration (ranging between 30 and 240 minutes) in order to observe the effect of such parameters on the structural capacity of fire affected box girder section. It has been found that type and duration of fire could have significant impact on the structural capacity of the prestressed box girder. A preliminary understanding of the effectiveness of a box girder section after a fire event can also be obtained from the outcome of the study. For instance, a web thickness of 200 mm or higher for hollow pc box girder, have been found to be effective for fire exposure considered in the study. However, further investigation with representative fire curves and variable parameters will be required to develop a comprehensive guideline.

Keywords: Box girder section, standard fire, hydrocarbon fire, thermal analysis, structural capacity, SAFIR.

SCREENING AND PRIORITIZATION FOR DETAILED SEISMIC EVALUATION OF LARGE STOCK EXISTING RC BUILDINGS

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Abstract. Past earthquakes, in developing countries, caused major destruction in masonry infilled RC buildings highlights the existence of a large stock of seismically vulnerable buildings. It is necessary to conduct seismic evaluation of these existing RC buildings to avoid future EQ damages. However, it is a challenge to conduct detailed seismic evaluation for a large stock of existing RC buildings due to several reasons, including requirements for detailed architectural and structural drawings along with other necessary information that are not available in most of the existing RC buildings. To reduce the limitations above, a rapid visual screening method, namely Visual Rating (VR) method, has been developed for screening and prioritization of the most vulnerable buildings for detailed seismic evaluation. The VR method estimates seismic capacity of existing RC buildings in terms of Visual Rating index (I_{VR}) which considers cross-sectional area and shear strength of vertical elements such as RC column, masonry infill wall, and RC wall as well as other building attributes such as structural configuration, deterioration, and building's age. This paper presents an application of the VR method on existing RC buildings located in Dhaka, Bangladesh. A total number of 1020 masonry infilled RC buildings are investigated and I_{VR} score has been calculated for all surveyed buildings. Buildings are categorized and prioritized for detailed evaluation according to I_{VR} score. It has been observed that about 35% of the surveyed buildings are categorized into less to highest priority of detailed seismic evaluation for retrofitting.

Keywords: Seismic capacity, Visual Rating method, Existing RC buildings, Masonry infill, Prioritization

BUILDING RESPONSE ASSESSMENT OF A HIGH-RISE RC STRUCTURE FOR THE AFTERSHOCK OF KOCAELI, TURKEY EARTHQUAKE - A CASE STUDY

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Abstract. Bangladesh is a seismically active region and tectonically located on the north-eastern Indian plate near the edge of the Indian pack and at the junction of three tectonic plates-the Indian plate, the Eurasian plate, and the Burmese microplate. High-rise reinforced concrete structures are vulnerable to collapse during earth-quakes. The main objective of the research is to investigate linear seismic responses of a high-rise RC structure due to long-duration earthquake ground motions, specifically in terms of drift and displacement. For this study, a 20-storied existing building will be selected and analyzed with The Kocaeli earthquake in Turkey in 1999, which caused significant damage to buildings and infrastructure in the region. This study involves a few steps to reach the main goal of this re-search. Primarily a three-dimensional finite element (FE) model will be developed using commercial FE software based on actual geometry, loading, and boundary conditions of high-rise structures following the Bangladesh National Building Code (BNBC 2020). The long-duration Kocaeli, Turkey earthquake ground motions were selected from the PEER ground motion data. The primary shock of the Kocaeli earthquake measured 19.18 inches, while the aftershock measured 35.10 inches. The aftershock wave drift is over 400% larger than expected. IDR is worth almost four times the designed earthquake. The design earthquake's torsional irregularity is controlled, yet it cannot resist the shockwave of the Kocaeli earthquake, which had a severe torsional irregularity of 1.4. These findings will help to assess the building considering drift and displacement for the earthquake and will conclude the need for effective measures to protect buildings and their occupants against these effects.

Keywords: Drift, Displacement, Kocaeli Earthquake, BNBC, Bangladesh, PEER Ground Motion.

CONDITION ASSESSMENT OF RC BUILDING AS PART OF STRUCTURAL HEALTH MONITORING (SHM) USING MICRO-TREMOR MEASUREMENT SYSTEM IN BANGLADESH: A CASE STUDY

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Abstract: Structural Health Monitoring (SHM) is a field of engineering that involves the use of sensors, algorithms, and data analysis techniques to monitor the condition of structures over time. The main goal of SHM is to detect any deterioration in a structure before it becomes critical, to prevent failure. This paper presents an investigation of a building's condition conducted by a microtremor measurement system to assess the structural health to quantify the potential damage or degradation risk during a seismic event: A case study. The microtremor unit consists of three units of 0.5-18 Hz frequency sensors, which are used to obtain data. Several measurements are conducted on the first floor of the building and the ground surface. Several peak frequencies are identified from three components of Fourier amplitude spectra computed by using GEODAS and GEOPSY software. By analyzing the data from the micro-tremor system, the natural frequency of the building and the soil are obtained. Additionally, the building resonances (R), soil vulnerability index (Kg) and building vulnerability index (Kbi) are also identified. These parameters help to identify the condition of a building to analyze the structural health monitoring during a seismic event. In this study, the resonance value of the building with the ground is between 3.03% ~ 15.58% with an average resonance value of 8.03% which is included in the high resonance. The location of the building is in an area with a Kg of 3.410~4.155, which is included in the category of moderate soil vulnerability index, and the Kbi has a value of 2.08 to 2.45.

Keywords: SHM, Earthquake, Micro-tremor, Building Resonance, Soil Vulnerability Index, Building Vulnerability Index.

PERFORMANCE ASSESSMENT OF PILE GROUP SUPPORTED HIGHWAY BRIDGES CONSIDERING SCOUR AND EARTHQUAKE HAZARDS

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Abstract. Scour is a common phenomenon for cross-river bridges and has a detrimental and complicated effect on the bridge, leading these bridges more prone to earthquake-induced damage by transferring the damage from columns to piles. The belowground pile damage is difficult to inspect and repair after an earthquake, resulting in a longer-term traffic disruption than their counterparts without scour. Acting as a critical joint in the traffic network, the bridge's in-earthquake safety is directly related to the traffic capacity of a transportation network after the disaster. In addition, soil pile interaction modeling and uncertainty modeling are crucial concerns of engineering and academic communities. Therefore, this study carried out the seismic performance assessment of pile group supported highway bridges in sandy soil with variable scour effects using the fragility approach. The finite element model for the pile group supported bridges considering the uncertainty of structural and soil parameters and ground motions is generated. After that, the seismic performance of the bridge with different scour depths is evaluated and compared. The result shows that scour makes the pile foundation more prone to earthquake-induced damage. The pile foundation could be changed as the most vulnerable bridge component with the increase of scour depth. However, the scour has a slight influence on the seismic fragility of the bearing and pier.

Keywords: Soil pile interaction, Bridge scour, Multiple hazards, Seismic fragility assessment, Pile group effect.

A COMPREHENSIVE OVERVIEW OF RISK FACTORS, CHALLENGES AND CONTROL MEASURES FOR WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG CONSTRUCTION WORKERS WORLDWIDE

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Abstract. Construction operations can account for up to 50% of total workplace injuries in some countries, so undeniably this is a major issue that requires immediate action. Given the complexities of construction work and the risks associated with it, construction work should be designed for occupational health and safety. This technique should be repeated throughout the construction process until everyone's health and safety is secured. Due to uncomfortable working postures, the use of excessive and repeated hand tools, and repetitive screw operations, among other factors construction has the highest risk of musculoskeletal injuries and disorders. The aim of this review is to examine the current research on Work-related musculoskeletal disorders (WMSDs) in construction workers, with a focus on the common causes of distress, risk factors, and prevention techniques. By integrating the existing research, this analysis will provide valuable insights into the current state of WMSDs among construction workers worldwide, and will help influence future research and intervention initiatives. As a result, the goal of this study was to raise construction employees' awareness of workplace safety hazards and injuries. Workers must be aware of the risk factors associated with WMSDs and to report any symptoms or incidents to their employers as soon as feasible. Ultimately, by emphasizing worker health and safety and collaborating to develop effective control mechanisms, it is possible to lower the frequency of WMSDs in the construction industry.

Keywords: Musculoskeletal disorder, construction safety, construction worker, risk factor, disability, muscle stress, awkward posture.

STRUCTURAL HEALTH MONITORING IMPLEMENTATION FOR PADMA BRIDGE: ADVANCING STRUCTURAL SAFETY AND MAINTENANCE STRATEGIES

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Abstract. Visual examination is the most often used method of bridge health monitoring. The notion of "structural health monitoring," or SHM, has grown in popularity over the last decade with the goal of providing information about the structural fitness and assisting in the understanding of their behavior. For any kind of infrastructure, safety must be considered the most important factor. Bangladesh is a river-bordered nation with several highway bridges, yet it is regretful that the SHM system has not yet been effectively installed on any bridges. The major objective of this endeavour is to design a structural health monitoring system for the Padma Multifunction Bridge. The drawbacks of interval-based inspection approaches may be mitigated by structural health monitoring, which also provides real-time diagnostic data about Padma Bridge's structural health. Recent advancements in the integration of structural health monitoring (SHM) with Intelligent Transportation Systems (ITS) demonstrate the effective use of ITS devices (such as traffic cameras and traffic detectors) in the analysis of bridge responses to multimodal traffic with varying loads or during critical events that cause excessive vibration beyond the normal limit, which can be of great assistance in preserving the Padma bridge's serviceability. By this integration, the likelihood of mistakenly diagnosing defects identified by the SHM system would be lowered, resulting in lower bridge maintenance expenses. Based on current research, this study provides a summary of the proposed monitoring system, its application, and applicability on the Padma Bridge.

Keywords: Structural Health Monitoring (SHM), bridge engineering, service-life evaluation, concrete girder, ITS, Padma Multipurpose Bridge.

PERFORMANCE, IMPACT, AND SIGNIFICANCE OF THE JAMUNA BRIDGE IN BANGLADESH'S INFRASTRUCTURE DEVELOPMENT: A COMPARATIVE ANALYSIS

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Abstract. Jamuna Bridge is a long-span bridge in Bangladesh that connects the districts of Tangail and Sirajganj across the Jamuna River. The bridge was constructed to resist a range of loads and strains, including the frequent high winds, strong currents, and earthquakes. This bridge has benefited the environment by lowering automobile emissions and boosting sustainable mobility. This has generated revenue and employment possibilities for the local community. Increased economic activity has resulted from enhanced connectivity, with more trade and commerce taking place between the two areas. The BBA's (Bangladesh Bridge Authority) routine maintenance and inspections, together with the SHM (Structural Health Monitoring) system put on the bridge, have been important in guaranteeing its continuing operation and safety. The upgraded infrastructure of the Jamuna Bridge has had a substantial beneficial effect, promoting economic growth and development, enhancing the safety and dependability of transportation, and enhancing the quality of life for the people of Bangladesh. Overall, the Jamuna Bridge has played a significant role in improving transportation and commerce in Bangladesh, linking rural regions and fostering economic progress.

Keywords: Jamuna bridge, structure, performance, structural health monitoring, impact, economic development.

EVALUATION OF THE COMPRESSIVE STRENGTH OF GENERIC AND GEOPOLYMER CONCRETE USING ARTIFICIAL INTELLIGENCE

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Abstract. In this study, the compressive strength of generic concrete and fly ash-based geopolymer concrete (GPC), made of cement by-products, has been compared using appropriate laboratory experiments and Fully Connected Multi-Layer Artificial Neural Network (ANN) models. The main objective is to predict the compressive strength by the models and compare the models based on accuracy. ANN is one of the well-known supervised-learning algorithms used in the field of artificial intelligence and it can effectively replace the current conventional labor-intensive time-consuming process of laboratory experiments. To prepare the experimental dataset, cylindrical specimens were prepared for generic concrete and GPC. The ANN model takes in fine aggregates, coarse aggregate, and sample size as the input for generic concrete and fly ash, slag, and sodium silicate solution for GPC to predict the output compressive strength based on the dataset used to train the network. All the experimental results and prediction models divulged that the ANN model trained for generic concrete had better accuracy with less error than the GPC one.

Keywords: Geopolymer concrete, Artificial neural network (ANN), Compressive strength, Fly–ash, Artificial intelligence.

DATA-DRIVEN BEARING CAPACITY PREDICTION OF SELF-DRILLING SCREW IN COLD-FORMED STEEL USING MACHINE LEARNING

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Abstract. Many branches of civil engineering are utilizing the benefit of machine learning (ML) techniques for solving complex problems such as predicting the capacity of fiber-reinforced concrete or steel connections. This paper presents an application of machine learning techniques in bearing strength prediction of self-drilling screw connections in cold-formed steel. Cold-formed steel and its structural forms are getting more popularity and interest from stakeholders because of their easier application, simple fabrication, and lower cost. An experimental database comprising 278 specimens has been developed from the conducted tests and existing literature. The database contains different features of the connections, explicitly end and edge distances, screw diameter and numbers, plate width and thickness, ultimate yield and ultimate strengths of the plates, and pitches along and perpendicular to the loading directions. Three ML-based regression models namely, linear regression (LR), ridge regression (RR), and support vector machine (SVR) are selected for the bearing resistance prediction of screw connections. Those models' performances are evaluated based on the coefficient of determination (R^2), adjusted R2 (Adj. R^2), root mean square error (RMSE), and mean absolute error (MAE). The result indicates that SVR performs the best among the proposed models, and the linear and ridge technique performs poorly. Connections bearing strengths predicted by the proposed models are also compared with the existing code-based formulas.

Keywords: Self-drilling screw, bearing capacity, machine learning, Support vector machine

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INSPECTION AND EVALUATION OF BRIDGES AND CULVERTS – AN INITIATIVE IN BANGLADESH

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Abstract. This paper presents the key findings of inspection and evaluation of bridges and culverts on the road network of the Roads and Highways Department (RHD) of Bangladesh. The Bridge Management Wing of the Roads and Highways Department completed the physical inspection of the structures in accordance to its Bridge Inspection and Evaluation Manual and fed the inspection data into the Bridge Management System (BMS) software. The evaluation reveals that most of the bridges and culverts in these two zones are in good condition. However, a critical number of bridges require emergency intervention to ensure uninterrupted road communication. This evaluation can be used to formulate a priority order for rehabilitation and strengthening that reduces costs due to reconstruction, improves climate change resilience, distributes funds based on severity of defects and importance of the bridge, and increases transparency in the management of the bridge and its infrastructure.

Keywords: Bridge inspection, bridge evaluation, bridge repair plan, bms, rhd.

THE IMPACT OF FRP ON FLEXURAL BEHAVIOR OF REINFORCED CONCRETE BEAMS: A COMPARATIVE STUDY OF DESIGN GUIDELINES

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Abstract. Fiber-Reinforced Polymer (FRP) strengthening has emerged as a promising rehabilitation technique for reinforced concrete (RC) beams. It is a cost-effective and environmentally friendly approach to maintain or enhance the structural integrity of buildings when functional requirements change or structural design deficiencies are identified. To ensure the accurate prediction of the strength enhancement provided by FRP, several guidelines and standards have been developed. However, the capacity predictions by these guidelines vary depending on several parameters, including the yield strength of steel, steel reinforcement area, thickness and number of FRP layers, dimensions of the structural members, etc. Therefore, this research paper aims to compare and assess the relative performance of the guidelines in predicting the flexural capacity of FRP-reinforced beams. Three most widely used design guidelines ACI 440.2R-17, ISIS Canada, and TR55 have been chosen in this study for comparison. The investigation is limited to studying the impact of four influential design parameters: the thickness of the FRP, steel yield strength, reinforcement area, and beam depth on the moment capacity of the strengthened beams. Results indicate that beam depth has the greatest impact on moment strength, while the increase in FRP thickness has the least effect. Moreover, the study finds that the ACI 440.2R-17 code predicts the highest moment capacity, whereas the ISIS code predicts the lowest in all cases.

Keywords: Fiber-reinforced polymer (FRP), ACI 440.2R-08, ISIS CANADA, TR-55, parametric study, beam.

IMPROVING STRUCTURAL PERFORMANCE AND DESIGN OF ALUMINUM TUBULAR MEMBER USING CFRP COMPOSITES UNDER WEB CRIPPLING LOADING

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Abstract. Carbon Fiber Reinforced Polymer (CFRP) is one of the most promising composite materials for strengthening aluminum and steel tubular structures. Most of the aluminum tubular member is experienced failure of web crippling under localize compressive concentrated loads. The load bearing capacity as well as structural performance is reduced due to local buckling of aluminum tubular member subjected to web crippling loading. Externally bonded CFRP strengthening may be considered overcoming this problematic local buckling. The aim of this study is to investigate improving structural performance and design of aluminum tubular member by CFRP composites under web crippling loading. This study mainly concentrates on the CFRP strengthening effects on aluminum tubular member by CFRP composites under web buckling loading. An extensive test programs have been conducted to strengthen the aluminum tubular member by CFRP composites under web crippling loading. Twenty-four aluminum tubular member including reference specimen were tested in this research with varying the influence parameters slenderness ratio. Load – deflection behavior, the failure loads, the failure modes have been presented due to concentrated loading. The load carrying capacity improved significantly and varied 34.6%-218% for different slenderness ratio and strengthening technique. ABAQUS software has been used to simulate CFRP, strengthening aluminum tubular member of the test results. In this study, Geometrical and Material non-linearity was included. Good agreement was reached between the tested results and the FE simulations. Developed finite element model, which is verified with test result, is used for parametric study using different sections and slenderness ratio. Design equation for aluminum tubular member using CFRP composites under web crippling loading is proposed. Hence, it can be demonstrated that the improving structural performance can be achieved for aluminum tubular member by CFRP composites strengthening under web crippling loading.

Keywords: Aluminum tubular section, CFRP, Design**,** Strengthening, Structural Performance, Web crippling

EVALUATİNG THE RESİDUAL CAPACİTY OF REİNFORCED CONCRETE COLUMN AFTER STANDARD FİRE EXPOSURE

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Abstract. This paper presents an approach to evaluating the post-fire residual capacity of re-inforced concrete columns by finite element analysis. Initially developed FE mod-el was validated against an experimental test result. The analysis was performed in two stages: first, fire exposure through thermal response; then, after cooling down, the structural response of the fire-affected specimen to determine the re-sidual capacity. Three different RC square columns with different reinforcement percentages (1%, 2%, and 3%) were analyzed. Each of these columns was ex-posed to a standard fire for 60 to 240 minutes. The outcome from this analysis shows that RC column residual capacity and stiffness decrease as fire exposure duration increases. The results show that for the first 60 minutes of fire exposure, the residual capacities of all RC columns were 56–68% of their nominal capaci-ties. Among the three column sections, it was observed that the residual capacity degraded faster in cases of columns with smaller cross-section. The residual ca-pacity obtained from FE analysis was finally compared with that calculated using simplified method. From the comparison it was found that, simplified method's prediction of after fire residual capacities were nonconservative for the RC col-umns exposed in fire for shorter duration

Keywords: RC Column, Fire, Residual capacity, Finite Element Analysis.

ENHANCEMENT OF AXIAL CAPACITY OF BRICK MASONRY COLUMN BY REINFORCED CONCRETE JACKETING

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Abstract. Masonry plays a vital role in construction, serving as either load-bearing or infill material in reinforced concrete or steel-framed buildings. In Bangladesh, brick masonry units are commonly used as load-bearing components, especially in rural areas. While capable of withstanding axial loads, brick masonry is not as strong when it comes to resisting lateral loads. With population density on the rise, there has been a trend of using agricultural lands for new building construction, which could be mitigated by vertically extending existing buildings. In this scenario, the capacity of the masonry columns must be increased. To achieve this, various methods can be employed, such as reinforcing the masonry wall using techniques like reinforced concrete (RC) jacketing. The study aimed to investigate the effectiveness of reinforced concrete (RC) jacketing in enhancing the axial compressive strength and ductility of brick columns. The study involved several types of specimens of similar sizes (114×114 mm^2 before strengthening and 240×240 mm^2 after strengthening) and four different types of bricks, with RC jacketing used for strengthening. The jacketing utilized 0.70% longitudinal reinforcement, and the specimens have been tested under monotonic loading. The study's results revealed that the axial capacity of masonry columns have been enhanced by approximately 150% with RC jacketing. Additionally, the average ductility enhancement has been found to be 38%. These findings indicate the effectiveness of RC jacketing in enhancing the load-carrying capacity and ability to resist deformation.**Keywords:** Load-bearing wall, Brick Column, Strengthening, Axial capacity, Ductility, RC jacketing

STIFFENING AND STRENGTHENING OF THE FRAME ELEMENTS OF SOFT GROUND STORIED BUILDINGS USING STRUCTURAL STEEL SHAPES

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Abstract. Reinforced concrete **(**RC) framed buildings are being constructed with infill walls on higher floors, leaving the ground floor (GF) open for parking spaces. This results in soft storey effects at the GF with considerably less stiffness than the stories above it, increasing the structure's vulnerability to seismic load, which is not considered in the general design process using equivalent static force method (ESFM). This study's goal is to determine the stiffness magnification needed to strengthen and stiffen structural elements of soft ground storied buildings using steel I-shapes to reduce storey drift within the permitted limit of BNBC 2020 and to analyze how this magnification changes with different structural parameters for various seismic zones in Bangladesh. To carry out the study, 2D models of RC-frames are developed using finite element software SAP 2000. The infill is modeled as compressive diagonal struts with varying infill percentages and distributed among the upper floors, leaving the GF exposed to develop soft storey effect on the GF. The variation in the magnitude of the stiffness requirement for both GF columns and beams at equal times is then studied and compared. The study shows that for greater infill percentages, stiffness magnification determined from response spectrum method (RSM) increases in the presence of infill on upper floors. Required stiffness magnification rises with span length until it hits a peak, then falls for zones 2, 3, and 4. The needed stiffness magnification, however, falls for zone 1 as the span length increases. In nearly all cases, a rise in the zone coefficient reduces the stiffness magnification.

Keywords: Strengthening, seismic load, stiffness, infill, retrofit, soft storey.

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PERFORMANCE-BASED DAMAGE STATES FOR SEISMIC RETROFITTING OF REINFORCED CONCRETE BRIDGE BENT

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Abstract. Performance-based seismic design approach is implemented to achieve a desired structural performance under a specific seismic hazard level. It requires defining a set of targeted performance levels and their corresponding limits. As current codes and guidelines do not prescribe such limits for different performance levels of bridges with seismic deficiencies such as inadequate ductility and low shear strength, this study aims to develop them. In this paper, quantitative damage states expressed in terms of maximum drifts at various performance levels are developed using incremental dynamic analyses for retrofitted bents. Four retrofit options e.g., steel, carbon fiber-reinforced polymer (CFRP), concrete, and engineered cementitious composite (ECC) jackets are considered in this study. Concrete and longitudinal reinforcement of all bents cracked and yielded at limiting drifts of 0.06% and 0.38%, respectively. Besides, the ECC jacketed bent experienced core crushing of concrete at the highest limiting drift of 4.16%. The developed damage states can be used for performance-based seismic retrofit design of seismically deficient bridge bents.

Keywords: Performance-Based Design, Seismic Retrofit, Damage States, Bridge Bent, Incremental Dynamic Analysis.

BOND STRENGTH PREDICTION OF EXTERNALLY BONDED CFRP LAMINATE WITH EMBEDDED BAR ANCHOR THROUGH PULL OUT TEST OF PRISM FOR SHEAR STRENGTHENING OF RC BEAM

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Abstract. Shear strengthening of RC beam using externally bonded Carbon Fiber Reinforcement Polymer (CFRP) is a common practice in construction industry. Debonding at concrete-adhesive interface is one of the major drawbacks in this method. Various anchorage systems had been investigated to prevent the debonding of externally bonded CFRP laminate. Embedded bar anchor system could be more effective to mitigate debonding of CFRP laminate. The main aim of the research was to investigate the bond strength of CFRP laminate with embedded bar anchor through pull out test of strengthened RC prisms. The effects of widths of laminate on bond strength of CFRP laminate with embedded bar were also investigated. In the experimental program, a total of 15 RC prism specimens were fabricated. The prism spemines were strengthened using 20 mm, 25 mm, 30 mm, 35 mm and 40 mm widths of CFRP laminate. Ebmedded bar of 6 mm diameter steel was used as anchors of all strengthened prisms. The specimens were tested under pull out load to investigate bond strength of externally bonded CFRP laminate with embedded bar anchor. Experimental results showed that the prism specimens failed by debonding of CFRP laminate at laminate-adhesive interface and crushing of concrete rather than debonding at concrete-adhesive interface. The maximum bond strength of CFRP laminate with embedded bar anchor was 3.12 MPa. The average bond strength of 20 mm, 25 mm, 30 mm, 35 mm and 40 mm width of CFRP laminates were 3.12 MPa, 2.77 MPa, 2.65 MPa, 2.03 MPa and 2.25 MPa respectively. Results also showed that lesser width of CFRP laminate had higher bond strength as compared to larger width of laminate.

FINITE ELEMENT INVESTIGATION ON THE EFFECT OF FRP STRENGTHENING ON CAPACITY OF STEEL SQUARE HSS COLUMNS

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Abstract. In this study, numerical finite element analysis was conducted to study the behavior of steel square HSS columns. The study focused on the effectiveness of reinforcing the columns with CFRP. A 3D FE model was developed using shell elements to represent the square HSS section. Extra layers of shell elements were added to the model to incorporate CFRP strengthening. Material and geometric nonlinearities were taken into account, and composite damage modeling was adopted for CFRP. The developed FE models were used to simulate experimental studies done by past researchers. Numerical analysis and previous experimental findings have shown to be in good agreement, establishing the validity and reliability of the current FE modeling scheme. Further parametric studies were conducted on non-compact AISC square HSS columns to observe the impact of CFRP layer count, slenderness ratio, and cross-sectional geometry on strength gain. Results indicated that increasing the number of FRP layers improves column capacity. Further, the study showed that the medium and smaller HSS sections benefit more from CFRP retrofitting than the larger sections. The research in the paper offers a cost-effective way to understand reinforced HSS sections with CFRP. It can help with implementing CFRP retrofitting for steel HSS columns.

Keywords: CFRP strengthening, Steel square HSS columns, CFRP damage model, Material and geometric nonlinearity, Axial strength gain, Hashin damage model

SEISMIC STRENGTHENING OF BRIDGE PIERS USING INNOVATIVE JACKETING METHODS: A CRITICAL REVIEW

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Abstract. Efficient and safe transportation relies on bridges, but many highway bridges worldwide are in poor condition and do not meet the current seismic design codes. Moreover, many bridges are located in high seismic hazard zones and were built before the implementation of modern seismic design provisions, and therefore lack the appropriate seismic detailing. Demolition or rebuilding these bridges to meet current codes requires significant expense and generates waste. Strengthening or retrofitting can be a cost-effective and eco-friendly alternative to demolishing or replacing. This paper aims to review the modern retrofitting techniques for a bridge pier such as engineered cementitious composites (ECC) jacketing, fibre-reinforced polymer (FRP) jacketing, and jacketing with shape memory alloy (SMA) bars along with their pros and cons. The scope of this review is limited to bridge pier strengthening using jacketing techniques.

BOND STRENGTH PREDICTION OF EXTERNALLY BONDED CFRP LAMINATE WITH EMBEDDED CONNECTOR THROUGH PULL OUT TEST OF PRISM FOR SHEAR STRENGTHENING OF RC BEAM

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Abstract. Embedded connector anchor has been used for shear strengthening of RC beam with externally bonded CFRP laminate in recent years. Interfacial bond strength of laminate is required to design the beam for shear strengthening using externally bonded method. The bond strength mostly depends on width of CFRP laminate for particular strength of concrete. The research aims to predict bond strength of CFRP laminate with embedded connector anchor through pull out test of RC prisms. In the experimental program, a total of 15 RC prism specimens were fabricated. The prism specimens were strengthened using 20 mm, 25 mm, 30 mm, 35 mm and 40 mm widths of CFRP laminate. Embedded connector of 16 mm diameter steel was used as anchor in all strengthened prisms. The specimens were tested under pull out load to predict the bond strength of externally bonded CFRP laminate. Results showed that all externally bonded CFRP laminate had failed by debonding of CFRP laminate at laminate-adhesive interface. The embedded connector anchor was effectively prevented debonding of laminate at concrete adhesive interface. The maximum bond strength of CFRP laminate with embedded connector anchor was 1.52 MPa. The average bond strength of 20 mm, 25 mm, 30 mm, 35 mm and 40 mm width of CFRP laminates were 1.512 MPa, 1.417 MPa, 1.52 MPa, 1.14 MPa and 1.157 MPa respectively. Results also showed that higher width of CFRP laminate exhibited lower bond strength.

EXPERIMENTAL INVESTIGATION ON CONFINEMENT OF CONCRETE USING LOW COST TECHNOLOGIES

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Abstract. The most important element in a structure is a compressive member. Sometimes the compression member's loading condition may change or due to the extreme weather condition, the member may experience a reduction in load carrying capacity. Also, due to earthquake, corrosion, crack in the concrete, material impurities, faulty mixtures and environmental pollution, the load carrying capacity can be further reduced. Failure of a compression member can cause global failure. Therefore, it is essential to make sure the compression members can carry their intended design load. Retrofitting and confinement is a great technique to solve this problem and restore the older structure to its required capacity. The main focus of this research is to investigate the performance and effectiveness of different methods of confinement on concrete using low cost technologies. To achieve this goal, a significant number of cylinders with various low cost confinement methods such as ferrocement confinement (single layer-full, single layer-partial, double layer-full), galvanized iron (GI) wire confinement (GI wire with mortar adhesive) and mortar confinement (different mixing ratio) has been cast and analyzed in this research. The cylinders were tested under uniaxial compressive loading and explored the effect of confinement on their structural behaviour. Test results for each specimen are illustrated in the form of compressive strength, crack patterns, stress-strain curves and modulus of elasticity. It is seen that the confinement of concrete by GI wire with mortar adhesive technique provides significant improvement of concrete strength, followed by ferrocement confinement and mortar confinement.

Keywords: Compression member, low cost technology, ferrocement confinement, GI wire confinement, mortar confinement, compressive strength, crack pattern

STATIC AND DYNAMIC BEHAVIOR OF FIBER REINFORCED RUBBERIZED RECYCLED CONCRETE COLUMN

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Abstract. The disposal of construction wastes from demolished structures, as well as waste tires from vehicles, is a major global concern that environmentalists and scientific communities need to be addressed. Reusing such types of structurally potential waste materials in new concrete production can provide a possible solution to promote a sustainable construction practice. The present study discusses the use of recycled coarse aggregate (RCA) and waste tire-derived crumb rubber (CR) along with polypropylene (PP) fiber in reinforced concrete (RC) columns by investigating its engineering application through a uni-axial compression test as well as a free vibration test. A series of five short columns having a size of 150 × 150 × 950 mm with a tie spacing of 150 mm had been tested. The main test variables were the content of CR (0, 5, 10, and 15%) with 0.5% polypropylene fiber and 30% RCA replacement. The axial capacity and its code comparison, toughness, ductility, damping ratio, and failure mode of each column were examined. Results revealed that the ductility was increased by up to 70% in fiber reinforced rubberized recycled concrete (FR^3C) columns, depending on CR replacement level. Besides, up to 301% higher damping ratio was achieved in FR^3C columns. Finally, this study will encourage engineers to use FR^3C in various structural members.

Keywords: Recycled coarse aggregate, crumb rubber, polypropylene fiber, axial capacity, ductility, damping ratio.

AN EXPERIMENTAL STUDY ON RAPID HARDENING CEMENT TO COMPARE WITH NORMAL HARDENING CEMENT

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Abstract: The advancement of modern technology requires the rapid construction of structures. For which we need early strength development of the structures. The main purpose of this research is to observe the need for speedy construction with a unique value proposition of rapid hardening cement (RHC) as compared to normal hardening cement (NHC). An experimental investigation is conducted firstly to examine the strength gain rate of different classes of RHC and NHC by compression test. Secondly, the structural performance of concrete beams constructed with different classes of concrete and types of cement (RHC and NHC) is investigated. Compression tests were conducted according to ASTM C39/C39M-21 [1] for the mix ratios 20 MPa, 30 MPa, and 40 MPa. The concrete cylinders were subjected to a 7, 14, and 28 days curing cycle and were tested on the 7^{th}, 14^{th}, and 28^{th} day. In the second phase of the research, beams were designed for a two-point loading flexure strength test using RHC and NHC and different concrete classes and were tested for flexural tests following ASTM C78/C78M-22 [2]. The specimens' behavior was observed according to the curing cycle. From the study, it was found that RHC gains 20% to 40% higher strength in 7 days compared to NHC. The deflection of concrete beams prepared with RHC will be within the serviceability limit if de-shuttered 10 days after casting. Early de-shuttering and faster construction reduces the cost of shuttering and manpower. However, curing must be continued for 28 days for achieving the full strength of concrete.

Keywords: Rapid hardening, curing, flexural test, de-shuttering, deflection, serviceability.

EXPERIMENTAL STUDY OF THE BEHAVIOR OF REINFORCED MASONRY WALL UNDER CYCLIC LOADING

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Abstract. Bangladesh is situated in a tectonically active region, making it susceptible to earthquakes. Unreinforced masonry structure (URM) is one of Bangladesh's most common structural typologies. Unreinforced masonry load-bearing walls are the main load-resisting elements of URM structures that are often designed to resist only gravity loads. Weakness in resisting lateral forces and the limited ductility capacity of these masonry structures make them more vulnerable to earthquakes. Integrating grouted reinforcement into masonry structures can be a viable solution. In this study, the behavior of reinforced masonry (RM) made of indigenous materials has been observed under cyclic loading to determine whether it can overcome the shortcomings of URM. An experimental laboratory investigation has been carried out to study the in-plane cyclic behavior of reinforced masonry structures, along with a detailed study of load-carrying capacity, stiffness, ductility, and energy dissipation of reinforced masonry structures. In this research, three half-scale reinforced masonry walls and three half scale unreinforced masonry wall have been constructed with three different cement to the sand ratio (1:2, 1:4, and 1:6). All the walls were subjected to lateral cyclic loading applied by a hydraulic jack. This experiment revealed that reinforced masonry walls had 3.4 to 5.3 times higher ultimate load-carrying capacity and 1.7- 3.3 times higher energy absorption capacity than unreinforced masonry walls. Furthermore, RM sustained nine complete cycles, whereas URM failed in the fourth cycle. This data suggested that RM walls exhibited a better seismic response than the URM walls.

Keywords: Reinforced masonry, cyclic load, load carrying capacity, ductility, energy dissipation.

CONSTITUTIVE MODELS OF SHAPE MEMORY ALLOYS FOR STRUCTURAL ENGINEERING APPLICATIONS

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Abstract. Shape memory alloys (SMAs) have recently gained significant attention from structural engineers, owing to their distinct features of superelasticity and energy dissipation capacity. SMAs are appropriate for usage as reinforcement in concrete structures and as key components in seismic protection systems due to their inherent properties. Several analytical and experimental investigations have shown that SMAs in various forms, such as rebars, wires, and plates, employed in diverse civil engineering applications can improve the seismic response of buildings and bridges. To effectively use SMAs in civil engineering structures and simulate their behavior precisely in finite element software, structural engineers must possess a comprehensive understanding of SMAs' behavior and select an appropriate constitutive model. Several studies have been conducted to develop constitutive models for SMAs to accurately predict the behavior of structures under various loading conditions. In this study, a comprehensive review of different constitutive models of SMAs is presented and their advantages and limitations are briefly compared. The outcomes of this study facilitate a thorough understanding of different constitutive models, enabling structural engineers to choose the best constitutive model based on their requirements to predict the behavior of structures more realistically.

Keywords: Shape Memory Alloys, Constitutive Model, Finite Element, Structural Engineering Application.

DEVELOPMENT OF DESIGN AIDS FOR THE DESIGN OF SIMPLY SUPPORTED POST-TENSIONED PC GIRDER

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Abstract. In this Sub-continent the use of pre-tension girders is not extensive and for maximum bridge-related projects, post-tension girders are widely used. Thus, a versatile design aid is needed for evaluating various combinations of these parameters to give preliminary options for both pre-tensioned and post-tensioned girders that will aid the designer in optimizing the final girder design. The bridge design manual of Precast/Pre-stressed Concrete Institute (PCI, 2003) provides preliminary design charts for selecting the girder size and pre-stressing strands based on the AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications concerning span length, girder height, and spacing, concrete strength, and strand diameter. The PCI charts are useful design aids but limit in that the charts can only be used for pre-tensioned girders. The procedure is demonstrated for simply supported post-tensioned pre-stressed concrete AASHTO I-beams–Type III, IV, V, VI, and custom type VII for normal strength concrete (NSC) and high-performance concrete (HPC) girders with 28-day compressive strength. It also involved pre-stressing strands of 0.5-in. (13-mm), 0.6-in. (15-mm) diameters and girder center-to-center spacing of 6-ft., 8-ft., 10-ft., and 12-ft. New LRFD design charts are developed to illustrate the procedure for computing minimum and maximum span length, number of prestressing steel/strands, girder spacing, and concrete strength on girder design. For validation purposes, results are compared with the preliminary design charts given in the second and third editions of the PCI Bridge Design Manual (PCI 2003, 2011).

Keywords: Pre-tension, post-tension, girders, pre-stressed concrete, bridge.

LATERAL CYCLIC RESPONSE OF SMA-BASED HYBRID STEEL BRIDGE PIERS: A PARAMETRIC STUDY

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Abstract. Bridge pier is the primary lateral force-resisting system of a bridge that experiences inelastic deformation during an earthquake. The use of Shape Memory Alloy (SMA) in steel bridge pier can help reduce seismic damage significantly through its self-centering capabilities. In this study, 3D finite element (FE) models were developed to compare the lateral cyclic response of steel column and SMA-steel hybrid column. A parametric study was also conducted to examine the effects of key design parameters such as the diameter-to-thickness ratio (d_c/t_c), the types of SMA, and the length of SMA in the buckling wavelength region on the strength, stiffness and ductility of hybrid steel bridge piers. The parametric study demonstrates that decreasing the diameter-to-thickness ratio (d_c/t_c) in SMA columns led to significant improvements in load capacity, stiffness and ductility. However, the effect of buckling wavelength on the lateral cyclic behavior of SMA-Steel hybrid steel columns was found to be dependent on the type of SMA materials used. Depending on the type of SMA material used, changing the buckling wavelength may or may not have significant effects.

Keywords: Steel bridge piers, shape memory alloy (SMA), seismic damage, parametric study, strength, and ductility.

MECHANICAL AND DURABILITY PROPERTIES OF GEOPOLYMER CONCRETE: A REVIEW

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Abstract. From an environmental and economic sustainability perspective, alkali-activated binder concrete (ABC) catches more attention and popularity as a replacement for ordinary Portland cement (OPC) due to its low energy intensity and 80% lower CO_2 emissions than OPC. This study assesses multiple research findings to examine how different aluminosilicate materials (particularly fly ash and ground granulated blast furnace slag) and various parameters, such as alkali solution-fly ash ratio, sodium silicate (Na_2SiO_3)/sodium hydroxide (NaOH) ratio, NaOH molarity, aggregate type and size, curing temperature, and duration impact the mechanical properties and durability of geopolymer concrete, highlighting its potential as an alternative to OPC despite its inherent limitations. The comparative studies reveal that ABC demonstrates high sensitivity to the chemical and physical properties of precursors and activators. This sensitivity arises from the influence of alkali content and reactive components in the source material during the geopolymerization process, which impacts chemical bonding, microstructural development, and ultimately the strength and durability of the concrete. But it has better performance in harsh environments and elevated temperatures. So, the strength and performance of ABC heavily rely on the optimal mixing proportions, including the appropriate range of base content and other parameters, as well as the curing methods employed. Therefore, standardized procedures and mixed designs with locally available raw materials need to be established for the wider application of geopolymer concrete.

Keywords: Alkali-activated binder concrete (ABC), Ordinary Portland cement (OPC), fly ash, alkali solution, curing condition, elevated temperature.

EFFECT OF VARIOUS SODIUM HYDROXIDE MOLARITY AND CURING CONDITIONS ON THE COMPRESSIVE STRENGTH OF INDUCTION FURNACE SLAG MORTAR

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Abstract. Induction furnace slag (IFS) is a byproduct of the manufacturing process of iron and steel, formed during steel production by using an induction furnace, which melts the metal using electrical energy. The application of induction furnace slag as a substitute for cement is a great resource utilization of industrial waste. This research aims to investigate the compressive strength of mortar cubes containing induction furnace slag and alkali activators as a replacement for cement to observe the variations in strength development. Three different molarities, i.e. 6M, 9M, and 12M, of sodium hydroxide solution are used with elevated (60 ̊C) and room (25 ̊C) temperature curing conditions. Twelve slag mortar cubes are cast for each molarity, and thirty-six cubes are cured for each curing condition and tested at different ages, i.e. 1, 3, 14, and 28 days, respectively. The outcome of the tests shows that slag cubes cured in high temperatures yield more strength, approximately 80-82%, within three days. In addition, it is also found that the variations in the molarity of sodium hydroxide also influence the strength where strength reaches an optimum level at 9M. The results reveal the potentialities of an environment-friendly alternative to the cement and cement hydration process.

Keywords: Induction furnace slag (IFS), sodium hydroxide, molarity, curing condition, and compressive strength.

BEHAVIOR OF BEAM-COLUMN JOINT IN FULLY ENCASED COMPOSITE COLUMN SUBJECTED TO CYCLIC AND MONOTONIC LOADING

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Abstract. Structural joints help to transfer the load and the moment from the beam to the column. Connections are denoted as one of the most important aspects of a structure to be designed. This study has attempted to develop a better understanding of the behavior of joints in a composite structure. The experimental study consists of beam-column joints in four fully encased composite column specimens, two are tested against monotonic, and two are tested against cyclic loading conditions. Each of the specimens consists of a structural steel beam section (100 x 75 x 5 x 5 mm) and a structural steel column section (100 x 90 x 5 x 5 mm) with a combination of four 16 mm bars as longitudinal rebars, and 8 mm bars as tiebars. The structural steel sections of the beam and column are joined by an extended endplate and four M20 bolts. 27 MPa concrete is used for each of the specimens to employ the composite action. The results and the designed specimens are validated against the AISC Design Guide 4, which has shown promising outcomes with acceptable deviations. It is observed that the composite specimens show a better performance in moment capacity against cyclic loading when compared to a bare steel specimen. Under monotonic loading, acute failure is observed, whereas cyclic loading induced progressive failure. Specimens subjected to cyclic loading have shown severe joint failure compared to the monotonic loading whereas early concrete failure is seen on each specimen regardless of the loading conditions.

EXPERIMENTAL INVESTIGATION OF PARALLELED DISC SPRING-BASED SELF-CENTERING VISCOUS DAMPERS

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Abstract. This study proposes an innovative paralleled disc spring-based self-centering viscous damper to address critical issues in the current self-centering bracing system and enhance structural resilience to earthquakes. The main attraction of the proposed damper is that the velocity-dependent viscous damping force is not a hindrance to the self-centering behavior of the structure after the ground motion. In addition, the SCVD is flexible in offering deformability and load resistance. First, the basic configuration, assembly steps, working principle, and simplified physical model are introduced in detail. Then the experimental study is carried out on two large-scale damper specimens. The damper shows a typical flag-shaped hysteretic behavior. The damper can fully achieve its self-centering behavior when the loading is finished. In addition, disc springs combined in parallel can significantly increase the load-bearing capacity and the post-activation stiffness of the SCVD. Finally, a numerical modeling technique is developed to capture the complex nonlinear behavior of the proposed damper. The multi-spring modeling strategy based on the simplified physical model has been proven to simulate the complex hysteretic behavior of the SCVD accurately. It can describe the mechanical characteristics that the activation displacement increases with the increase in loading velocity.

Keywords: Seismic resilience, disc springs, self-centering, viscous energy dissipating mechanism, damper

PERFORMANCE OF CONCURRENT SHEAR WALL AS A BRACING SYSTEM TO RESIST LATERAL LOAD ON SUPERTALL STRUCTURES

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Abstract. Tall building structural solutions have developed in such a way that they competently improve lateral stiffness against lateral forces, and especially against wind loads. Around the world, tall buildings are continually being developed to reach ever-higher heights. As a result, structural systems have seen several advancements. This work aims to determine whether Bangladeshi structures taller than the nation's current tallest tower can be built using a novel structural system named the Concurrent Shear Wall System. This idea requires the placement of several concurrent shear walls linked by beams and RC floor slabs in both directions. Vertical cantilevers are formed by linking the shear walls closely all the way to the foundation. Its performance is then compared with the Bundled Tube System as the current world's tallest structure is constructed using this. Based on the outcomes of numerical calculations carried out with the use of the tool ETABS, the Concurrent Shear Wall System significantly decreases displacement and drift(both decrease more than 20%), making the structure more rigid and stiffer(more than double that of the popular Bundled Tube system). Increased shear wall thickness results in less displacement and drift and noticeably increased stiffness at a lesser cost of materials. Its high in-plane stiffness and strength make it the potential best option for bracing systems. This opens up the possibility of using this system for even taller structures (200+ stories).

Keywords: Tall buildings, stiffness, strength, deflection, drift, concurrent shear wall, bundled tube system.

NON LINEAR FE INVESTIGATION OF HSS COLUMN BASE PLATE CONNECTION

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Abstract. The column base plate is a vital component in steel structures as it is responsible for transferring and distributing the entire load from the superstructure to the foundation. This connection plays a critical role in transferring both lateral and axial loads to the underlying foundation system. Any failure in this connection can cause the entire structure to collapse. However, the current design guidelines provided by *AISC Steel Design Guide One* have some limitations and fail to address certain issues such as the provided formulations computes an average value of tensile forces for all the tension bolts and does not provide methods to determine the tension bolts in an inner row of bolts. To overcome these limitations, this research aims to investigate the behavior of base plate connections with HSS (hollow steel section) columns under lateral loading with the aid of finite element analysis. The objective is to address the limitations of the design guideline and to observe the actual tension distribution in the bolts. A Nonlinear Finite Element Model has been developed in ANSYS and validated using previous experimental data, demonstrating its accuracy and reliability.

Comparative studies have been conducted, comparing base plates with different thicknesses and two anchor rod layout patterns. The numerical findings from the model are compared with the experimental evaluations proposed in previous studies. Additionally, the role of anchor rods in resisting tension is examined. Studies conclude that for thicker base plates, a linear relationship can be established between numerical and experimental findings. In base plates with low thickness, an increase in column deflection results in a higher contribution of anchor rods in resisting tension. In addition, it is observed that for a given base plate thickness, the ratio of tension resisted by inner rods to outer ones is higher for an eight-rod layout compared to a twelve-rod layout.
Overall, this research provides insights into the behavior of base plate connections with HSS columns and discusses methods to address the limitations of existing guidelines. The findings contribute to enhancing the safety and reliability of steel structures by improving the understanding of base plate behavior and optimizing their design.

Keywords: Column base plate, steel structures, finite element, connection, Lateral Load

THE IMPACT OF FOAM CONCRETE DENSITY ON THE HYGROTHERMAL PERFORMANCE OF BUILDINGS: A SIMULATION STUDY

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Abstract. This study aims to evaluate the hygrothermal performance of a whole building by simulating the heat and moisture transfer using WUFI Plus software. Specifically, the study investigates the use of foamcrete as an insulation layer in a 226mm thick concrete wall, with densities ranging from 400-800 kg/m^3. For hygrothermal simulation, Harbin and Guiyang city of China having extreme cold and hot climatic conditions were selected. The novelty of this research lies in its focus on the use of foamcrete with different densities as an insulation material in concrete walls. While foamcrete has been used as an insulation material before, this study contributes to the existing body of knowledge by evaluating the hygrothermal performance of the entire building, rather than just the insulation material itself. Additionally, the study investigates the effect of varying foamcrete densities on heating and cooling loads, which has not been extensively studied. The results show that the addition of foamcrete, irrespective of density, significantly improves the heating and cooling load of the building. Wth the use of 400 kg/m^3 foamcrete as an insulation material, the heating load was reduced by 53.342%, while the cooling load was reduced by 26.8%. While the reduction in heat flow ranges from 37.8% for FC-0.8 walls to 55% for FC-0.4 walls when compared to the reference model. These findings have significant implications for the design and construction of energy-efficient buildings. By demonstrating that foamcrete with lower densities can reduce heating and cooling loads in a building, this study suggests that foamcrete can be a viable option for insulation in concrete walls, which can help reduce energy consumption and related costs in buildings.

Keywords: Foam concrete, hygrothermal simulation, WUFI plus, energy efficiency, sustainable building design, building performance

ULTIMATE COMPRESSION CAPACITY OF UNBONDED STEEL-MESH REINFORCED RUBBER BEARINGS

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Abstract. Unbonded elastomeric bearings are commonly used in highway bridges in developing countries. However, they tend to slide uncontrollably during strong earthquakes. To this end, a novel bearing called the Unbonded Steel-Mesh Reinforced Rubber Bearing (USRB) is proposed. USRB applies flexible high-strength steel wire meshes, typically used in tires and screens, as reinforcement. This allows for controlled rolling of the elastomeric bearings to enable larger lateral deformation capacity and lower lateral stiffness. Nevertheless, the effect of the steel mesh reinforcement on the vertical properties of USRB, particularly the ultimate compression capacity, remains unexplored. Therefore, this paper studied the ultimate compression capacity of USRB through experimental and numerical methods. One USRB prototype was fabricated and tested to identify the failure mechanism under vertical compression. Finite element modeling was then conducted to investigate the influence of various reinforcement characteristics on the ultimate compression capacity of USRBs, such as steel wire diameter, aperture size, and weight per unit area. The test demonstrates that USRB fails due to the tensile failure of steel wires in the mesh reinforcement. The FE results show that the mesh reinforcement can provide USRB with higher ultimate compression capacity by applying larger steel wire diameters, higher weights per unit area, and smaller aperture size. However, the superior lateral performance of USRBs is at the sacrifice of a lower ultimate compression capacity compared to steel-plate reinforced bearings. This study provides a research basis for the application of USRBs in bridges with high load demand, and also demonstrates their potential to improve the seismic isolation performance under vertical seismic loadings.

Keywords: Isolation bearings, fiber-reinforced elastomeric isolators, unbonded steel-mesh reinforced rubber bearings, ultimate compression capacity, finite element model, failure mechanism, influence factor.

REVISITING THE SHEAR DESIGN PROVISIONS FOR FRP-RC DEEP BEAMS WITHOUT STIRRUPS

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Abstract. The shear behavior of FRP-Reinforced Concrete (RC) beams is different than that of conventional RC beams because of the smaller modulus of elasticity and brittle elastic failure of FRP rebars. To anticipate the shear strength of FRP-RC deep beams, many models, codes, and guidelines have been established. The majority of existing shear design provisions for FRP-RC deep beams are empirically calculated or calibrated based on limited test results. This paper develops an improved database consisting of 162 experimental and 93 numerical datasets to evaluate the performance of existing design provisions in predicting the shear strength of RC deep beams without stirrups that are internally reinforced with longitudinal FRP bars. The performance of each model was assessed based on the statistical parameters. Based on the analysis, the existing codes, standards and guidelines are found to be extremely conservative but safe for design. On the other hand, although few proposed models performed better than the existing codes, standards and guidelines in terms of mean and other statistical parameters, these models returned high percentages of unconservative results.

Keywords: Fiber-reinforced polymer (FRP) bar, reinforced concrete, deep beam, shear-span to depth ratio.

STRENGTH COMPARISON OF CONCRETE CYLINDERS AND CUBES INDUCED WITH DIFFERENT DEGREES OF STEEL FIBERS

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Abstract. According to studies, steel fiber reinforced concrete is effective at lessening the brittleness of concrete. Steel fibers have been discovered to boost concrete's compressive strength and prevent cracking when added to the material in particular amounts. By incorporating various percentages of steel fibers into concrete, this study sought to ascertain and compare the variation in compressive strength between regular concrete and steel fiber reinforced concrete. Concrete cylinders and cubes have been the subject of experimental research on the increase in compression capacity and load deflection behavior of Steel Fiber Reinforced Concrete (SFRC). For this aim, control specimens made of plain concrete are tested for relative compression strength together with SFRC members formed of fibers with an aspect ratio of 55 that have been prepared for concentric and eccentric loading. Because the concrete contains steel fibers, its compressive strength has been significantly increased. Stone chips (20 mm) were utilized to prepare the concrete. The study's specific goal was to test the compressive strength of concrete cylinders and cubes that contained different amounts of steel fiber (0%, 0.3%, 0.5%, 1%, 1.5%, and 2% of the concrete's total weight). The specimens' compressive strength was evaluated after 3, 7, and 28 days. In this study, other material tests were also carried out to learn more about the characteristics of the materials, and the slump test was used to gauge the workability of the concrete. According to studies, the strength of plain concrete is less than that of steel fiber reinforced concrete, and the compressive strength of steel fiber reinforced concrete cylinders and cubes improves as the amount of steel fibers in the concrete increases.

Keywords: SFRS, Compression test, Slump, Concrete, workability, steel fiber

IMPACT LOADING EFFECTS ON THE UPPER CERVICAL SPINE UNDER DYNAMIC AND STATIC CONDITIONS USING FINITE ELEMENT ANALYSIS

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Abstract. Work-related musculoskeletal disorders **(**WMSD) are a significant global concern, accounting for a third of occupational accidents and illnesses that lead to work absences. In particular, injuries to the cervical spine pose a significant risk of disability or even death. This study aimed to examine the mechanical behavior of the cervical spine in response to changes in the material properties of key cervical ligaments. By modifying the properties of the annulus fibrosis and nucleus pulposus, the stress distribution on the interior and posterior sections of the C2-C3 model was simultaneously identified in progressive degeneration scenarios. A finite element (FE) model was developed for the C2-C3 cervical spine segment, incorporating realistic material properties and validated in various scenarios including flexion, extension, axial rotation, and lateral bending. This model was then used to evaluate spinal load-sharing during pure compression and sagittal flexion/extension at different impact rates. The study revealed that in all cases, the capsular ligament (CL) experienced the highest stress among the ligaments. During lateral bending or axial rotation, the CL with lower stiffness caused greater intervertebral disc pressure (IDP), while the CL with higher stiffness resulted in lower IDP. As disc degeneration progressed, intersegmental rotation decreased for all loading scenarios, with weakly deteriorated discs leading to increased rotation. The study also highlighted the importance of prioritizing safety in the construction industry, as accidents can lead to fatalities and project delays.

Keywords: Biomechanics, spinal cord injury, construction worker, FE analysis, cervical spine, disc degeneration.

PARAMETERS CONTRIBUTING TO THE STRENGTH REDUCTION OF SELF-CENTERING CONCRETE BRIDGE PIERS

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Abstract. In this study, the strength reduction of the self-centering concrete bridge piers due to lateral loading is evaluated using 3D finite element modeling. The strength reduction of a self-centering concrete bridge pier depends on several factors, like concrete strength, prestressing force level, concrete confining jacket thickness and steel ratio of the pier. This study focused on finding the contribution of these parameters in the strength loss of the self-centering pier and finding the interaction among these parameters. After validating the FE model, a detailed parametric study has been conducted using the method of factorial analysis. The result from the factorial analysis is used to find the contribution and the interactions between the parameters of the self-centering pier. The results show that among the considered parameters the jacket thickness has the highest contribution to the base shear loss of the pier and the longitudinal steel has a very minor contribution to the strength loss of the pier.

Keywords: Self-centering, Concrete Bridge Pier, Factorial Analysis, FE Modeling.

EFFECT OF LAPPING IN REINFORCEMENT IN ONE-WAY REINFORCED CONCRETE SLABS WITH WELDED WIRE

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Abstract. This paper investigates the effect of lapping in reinforcement under pure bending in Welded Wire Reinforced (WWR) slab panels in comparison to slabs reinforced with 10 mm dia conventional deformed rebar. Six one-way simply supported slabs with a dimension of 2.286 m X 0.762 m and reinforced with 6 mm dia WWR, 8 mm dia WWR and 10 mm dia conventional deformed rebar were experimentally evaluated to compare the flexure capacity. The results show that 6 mm dia WWR and 8 mm dia WWR specimens with and without lapping in reinforcement exhibited similar load carrying capacity in terms of flexural strength. But in case of 10 mm dia conventional deformed rebar, flexural strength is a little higher for the slabs reinforced with lapping in reinforcement. Although, each of the slab panels were designed using equivalent reinforcement and similar grade, a higher load carrying capacity of the slab panels was recorded due to increase in diameter and ductility class of rebars. One of the major characteristics of WWR is uniform crack distribution which is decreased considerably due to the addition of lapping in reinforcement. Conventional 10 mm dia deformed bar does not exhibit uniform crack distribution during application of load. Each of the slab panels conformed to the allowable deflection criteria at the serviceability limit state. Based on the experimental findings of this study, lapping in reinforcement of one-way RC slabs reinforced with WWR has insignificant effect on flexural capacity but the uniform crack distribution property of WWR is significantly reduced due to lapping in reinforcement.

Keywords: Welded Wire Reinforcement, Lapping in Reinforcement, One-way Slabs, Stress Concentration.

EFFECT OF THERMO MECHANICALLY TREATED (TMT) BARS IN LOW AND MEDIUM STRENGTH CONCRETE BEAMS

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Abstract. Thermo Mechanically Treated (TMT) bars with tensile strength above 500 MPa bars are optimized to be compatible with Concrete with strength above 25 MPa. In local constructions in Bangladesh, high strength TMT bars of 500 MPa or above is used commonly integrated with low strength concrete. Although designers set the criteria for concrete to have strength above 25 MPa according to code but due to poor workmanship, practically its strength degrades. In this study, the performance of 500 MPa steel and 420 MPa steel was compared on both 15 MPa and 25 MPa concrete based on Strain Compatibility, Deflection, and Flexural stress capacity. The parameters were tested in beams of both medium strength and low strength concrete for both TMT bars of 500 MPa and normal rebar of 420 MPa. The calculated moment capacity was compared with the observed values of the parameters. Possible reasons for obtaining such results were also investigated. This study discusses the effect of TMT bars with medium and low strength concrete compared to normal strength bars of 420 MPa strength. It also explores opportunities for further improvement in the practical scenario in Bangladesh, describing which type of bars would perform better in different purposes and types of construction. The study specifically focuses on the compatibility of TMT bars with low strength concrete, providing insights for selecting the better option for practical use. **Keywords:** TMT bar, strain compatibility, low strength concrete, flexural stress, deflection, beam test, two-point loading

UTILIZING TAX-PAYER FUNDS EFFICIENTLY: SELECTION OF SUPERPAVE BITUMINOUS BINDER FOR HIGHWAY CONSTRUCTION IN BANGLADESH

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Abstract. Many countries worldwide use Superpave Peformance Grade or Viscoitty Grade Bitumen for street and highway construction. Unfortunately, we still use penetration grade bitumen in construction streets and highways in Bangladesh. Numerous scientific studies reported using penetration grade binder is not sustainable and insufficient for building long-lasting pavement. This century-old system can not evaluate binder performance in different climatic scenarios as binder performance is selected based on one temperature. Furthermore, in this system, no aging and fundamental and engineering properties are obtained – essential for understanding long-term pavement performance. This current study attempts to select superpave performance grade bitumen for different regions in Bangladesh based on climatic data. All the necessary climate data of different stations located all over the country are collected from the Bangladesh Meteorological Department. Two models- SHRP and LTPP were employed to predict pavement minimum and maximum temperature. Performance grade (PG XX-XX) binders were selected from the average seven-day maximum and minimum temperature, which were predicted using two separate models. The selected performance grade binders for 23 locations across Bangladesh are outlined in this article.

Keywords: Bituminous Binder, Penetration Grade, Climate Data, Pavement Temperature Prediction, Performance Grade Binder.

COMPRESSIVE BEHAVIOUR OF SLENDER DISCONTINUOUS DOUBLE STEEL TUBE CONFINED CONCRETE COLUMN UNDER CONCENTRIC LOADING

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Abstract. This paper numerically investigates the compressive behaviour of a new form of Double Steel Tube Confined Concrete (DSTCC) column where the inner Concrete Filled Steel Tube (CFST) is confined by a discontinuous steel tube and a sandwiched concrete core. In this configuration, the discontinuous steel tube will not carry any axial load directly rather it is supposed to provide adequate confinement to the CFST column. In addition, due to the discontinuity of the outer steel tube, the occurrence of the local buckling near the supports could be prevented. As a result, the axial load-carrying capacity of the proposed Discontinuous Double Steel Tube Confined Concrete (DDSTCC) column would be enhanced as compared to the conventional (DSTCC) column. Till date, very little attention has been paid to investigate the compressive behaviour of this type of column. Thus, the aim of this study is to develop a comprehensive finite element (FE) model in ABAQUS by considering both geometric and material nonlinearities to investigate the compressive behaviour of slender DDSTCC columns under concentric loading. The developed FE model was first validated against the existing test results and then it was adopted to carry out a parametric study to investigate the effect of various key parameters on the compressive behaviour of the DDSTCC column which includes thickness of outer and inner steel tube, different grades of concrete. It can be observed that the concrete's compressive strength has significant influence on the ultimate load, whereas the thickness of the steel tube contributes to residual load carrying capacity of the column.

Keywords: Discontinuous double steel tube confined concrete, compressive behavior, finite element analysis, slender, confinement effect.

LATERAL TORSIONAL BUCKLING STRENGTH OF HIGH STRENGTH STEEL BEAM UNDER VARIOUS MOMENT GRADIENT

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Abstract. To date, many research studies related to the Lateral Torsional Buckling (LTB) behavior of Normal Strength Steel (NSS) beams have been conducted, and therefore, the guidance for calculating the LTB strength of NSS beams is quite comprehensive in the existing design codes. As the application of High Strength Steel (HSS) (yield strength, $f_y \geq 690$ MPa ≈ 100 ksi) has become increasingly popular due to its superior strength-to-weight ratio, many design standards allow the use of HSS with grades up to 690 MPa. However, AISC 360-22 does not endorse the use of HSS due to the lack of adequate experimental or numerical investigations that necessitate the evaluation of the LTB strength of HSS beams. Thus, this research numerically examines the LTB strength of HSS I-shape beams under various moment gradients. A detailed three-dimensional finite element (FE) model of HSS I-beams was developed in ABAQUS, considering both geometric and material nonlinearities. As HSS exhibits different material and residual stress characteristics than NSS, experimentally measured material properties and residual stress patterns specific to HSS were incorporated into the model. Initially, the developed FE model was validated using existing test results, after which it was utilized to conduct a thorough parametric study. In the parametric study, a broad range of parameters, including the grades of steel, length of the beam, and linear and non-linear moment gradients, were considered to determine the LTB strength of HSS beams. Finally, the extracted numerical results were compared with the values acquired from the existing LTB strength equations of AISC 360-22.

Keywords: Lateral torsional buckling, high strength steel beam, finite element analysis, non-linear analysis, AISC 360-22, residual stress

LIFE CYCLE ASSESSMENT OF RIGID AND FLEXIBLE PAVEMENTS: A REVIEW IN BANGLADESH PERSPECTIVE

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Abstract. The construction sector is a significant user of environmental assets and a substantial contributor to CO_2 emissions, with pavement construction having a major impact. As more emphasis is placed on sustainability and resource preservation, present construction processes must be evaluated in terms of sustainability impact. The judgment process for pavement construction is heavily influenced by initial costs, operation costs, maintenance costs, and sustainability practices. The present research examined the life cycle assessment of flexible and rigid pavements. The findings reveal that the initial cost of rigid pavement is on the higher side compared to flexible pavement. However, flexible pavements required frequent maintenance over time; on the contrary, rigid pavements need negligible maintenance. Nevertheless, flexible pavements have a 1.3 times higher carbon footprint than rigid pavements. Finally, it can be stated that rigid pavement is more economically viable than flexible pavement when viewed as an LCC.

Keywords: Life cycle assessment, flexible pavements, rigid pavements, CO_2 emission, and alternative material.

A REVIEW ON THE COMPRESSIVE & TENSILE STRENGTH OF DIFFERENT FIBER-REINFORCED CONCRETE

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Abstract. Concrete is becoming an important construction material all over the world. Concrete's superiority over other construction materials is owing to its high compressive strength, as well as additional benefits such as water resistance, low maintenance costs, ease of molding to desired size and shape, low cost, and low energy input during manufacturing. However, the material's reduced tensile strength and brittle nature are considered its significant drawbacks. Concrete reinforcement is the greatest approach to keep tensile-stressed concrete from cracking. Increasing the ductility of concrete by reinforcing it with discrete fibers that are randomly placed is a viable option. The main aim of the study is to compare the concrete property of different types of fibers (steel fiber, jute fiber, glass fiber, coconut fiber, nylon fiber, bamboo fiber) in concrete from different literature. It may conclude from different researchers that steel, glass, nylon, polypropylene, jute, and bamboo fiber-reinforced concrete showed higher compressive and tensile strength when the fiber-cement ratio was 3%, 0.75%, 0.5%, 1.5%, 0.1%, and 2% respectively.

Keywords: Fiber-reinforced concrete, compressive strength, tensile strength, fiber-cement ratio, tensile crack.

COMPARATIVE ANALYSIS OF MACHINE LEARNING ALGORITHMS FOR PREDICTING COMPRESSIVE STRENGTH OF CONCRETE CONTAINING SILICA FUME AND METAKAOLIN

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Abstract. Silica fume and metakaolin have been proven effective supplementary cementitious materials to reduce the carbon footprint and promote sustainability while ensuring the strength and durability requirements of concrete. This research aims to provide a comparison among different variants of supervised learning algorithms to predict the compressive strength of concrete mixes incorporating metakaolin and silica fume. To conduct the training and testing phase of the study, datasets from published literature were used, including results from 195 samples having thirty-three different mixture proportions. The data was structured in a format consisting of eight input parameters. Random Forest and Gradient boosting were performed based on ensemble learning and Bayesian Ridge regression based on statistical learning to predict the compressive strength of concrete. The analysis revealed that random forest demonstrates better prediction on the testing set among the other four algorithms, with an R^2 square of 97.4 %, RMSE of 3.65 MPa, an MAE of 2.79 MPa, and an MAPE of 4.41%. In conclusion, ensemble algorithms have the best predictive ability to predict the value of compressive strength concrete specimens using silica fume and metakaolin as partial substitutes for cement.

Keywords: Concrete, compressive strength, silica fume, metakaolin, predictive modeling, machine learning.

COMPARATIVE NUMERICAL STUDY ON CONCRETE-FILLED STAINLESS STEEL TUBULAR (CFSST) COLUMNS WITH SQUARE SECTIONS EXPOSED TO FIRE

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Abstract. This paper presents the behavior of concrete-filled stainless steel tubular (CFSST) columns with square cross-sections exposed to fire. Behavior of CFSST columns under fire was simulated by sequentially coupled thermal-stress analysis procedure carried out using Finite element software "Abaqus". Initially the developed numerical models were validated with experimental results avalable in literature based on temperature distribution with time, axial deflection versus time curves, and failure modes. Later, fire resistance times of CFSST columns of different grades of stainless steel were evaluated for ISO 834 standard fire. Among them, the performance of austenitic grade was found better than ferritic and duplex grades. The other parameters explored in the test program included cross-section dimension, axial load ratio (0.60–0.75), and the ratio of steel to concrete (0.056-0.085). The findings of these parametric studies are later addressed in the paper and the fire responses for possible sets of variables are evaluated.

Keywords: Stainless steel, concrete-filled, stub column, finite element, thermal stress analysis, fire resistance time.

STRENGTH AND WORKABILITY OF NORMAL STRENGTH CONCRETE WITH INCREASING AMOUNTS OF FINE AGGREGATE FOR DIFFERENT WATER-CEMENT RATIOS

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Abstract. Conventional concrete mixes (1:1.25:2.5, 1:1.5:3, 1:2:4) used in Bangladesh contain a very high amount of course aggregate (CA) making the price of concrete very high in the current market. This paper presents an experimental study to determine the effect of the fine aggregate to total aggregate (FA/TA) ratios on the strength and workability of normal-strength concrete for different water-cement (w/c) ratios. Two different w/c ratios of 0.45, and 0.5 were used. For each w/c ratio, the FA/TA ratios were varied from 0.35 to 0.5. Test results show that the workability of concrete decreased with the increase in FA/TA ratios. However, the compressive and tensile strength of concrete increased with the increase of the FA/TA ratio. Moreover, considering the present market values of the materials in Bangladesh, a higher FA/TA ratio results in lower costs for concrete.

Keywords: Concrete, mix design, fine aggregate, water-cement ratio, compressive strength, workability.

THE POSSIBILITY OF A RADICAL CHANGE IN THE CONSTRUCTION SECTOR: IN EMERGENCE OF SAND-CEMENT BLOCK AGGREGATE, COMPARATIVE STUDY OF ITS MECHANICAL PROPERTIES

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Abstract: The recent impetus from the Government of Bangladesh is making the private sector of sand-cement blocks grow rapidly. With its growth in production and use in construction, different challenges are emerging. The use of clay brick aggregate as an alternative to crushed stone in concrete has been a common practice in Bangladesh. The availability of sand-cement blocks has presented another aggregate source into the market. In this work, investigations have been made to get a close look at the possibility of using block aggregate in concrete. For the Study, block aggregate alongside crushed stone aggregate and clay-brick aggregate were studied together. All of the aggregates went through characteristic tests including gradation, moisture content, water absorption, crushing value, and abrasion loss. Then concrete cylinders for all types of aggregate were made in a 1:1.5:3 ratio and the mechanical properties of concrete were inspected with compressive strength. This work provided an in-depth look into a crucial issue in the construction sector. We have found, the workability of sand-cement block aggregate to be similar to that of stone. For compressive strength, it was comparable to that of brick aggregate at 28 days. The areas of use for block aggregate are found to be highly restricted by its high crushing values and Los Angeles abrasion values.

Keywords: Alternate aggregates, Mechanical property, Workability, Compressive strength

INVESTIGATION ON THE MECHANICAL PROPERTIES OF POWER-PLANT BASED HIGH VOLUME FLY ASH CONCRETE

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Abstract. Concrete incorporated with a high amount of fly ash uses less cement and has a mechanical strength that is suitable for standard construction. High volume fly ash concrete (HVFAC) has lately been more widely used as a resource-effective, long-lasting, and sustainable solution for a number of concrete applications. The behavior and strength observation of HVFAC is the main topic of this research. Fly ash can substitute traditional Portland cement in various amounts, such as 50%, 60%, 70 % and 80% respectively with 100% Portland cement serving as the control concrete. The objective of this research is to examine how fly ash affected the workability, compressive and splitting tensile strengths of concrete for different concrete mixtures and at different curing periods. The water cementitious ratio was kept as 0.45 throughout the mixtures and a water reducing admixture namely Sulfonated Naphthalene Formaldehyde was used as 0.8% (obtained by trail and error) of the total binding materials to increase the workability. A total of 90 concrete cylindrical specimens (100 mm × 200 mm) were cast and tested for this research. As the concrete was being made, the changing of slump value was observed with the increasing of fly ash content and the mechanical characteristics such as compressive and splitting tensile strength were assessed at 7, 28 and 56 days. Based on testing results comparing HVFAC to conventional concrete, HVFAC provides less variation of strength than conventional concrete at long term ages and in accordance with cost analysis, it is significantly less expensive than control concrete and it is suitable for warm weathers and where early strength is not essential.

Keywords: Fly ash, HVFAC, Water cement ratio, compressive strength, splitting tensile strength, economical.

APPLICABILITY OF IRON SLAG AS COARSE AGGREGATE IN CONCRETE PRODUCTION

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Abstract. The continuous extraction of aggregates from natural sources to produce concrete, a widely used construction material, poses a threat to the environment. Historically, stone or brick chips and sand are used as the coarse and fine portions of aggregate in concrete production. Whether it is stone chips, directly obtained from natural sources, or brick chips, obtained from the clay burn brick, it can result in an imbalance in nature. However, as the aggregates act as the filler material in concrete, any inert material can also be thought to serve the purpose. Aiming for a greener environment and sustainable solution, the application of waste materials in concrete production should be focused in the coming days. This study aims to explore the applicability of iron slag in concrete production as a substitute for conventional coarse aggregates. Physical properties of iron slag, i. e. dry density, grain size distribution, absorption capacity, and specific gravity values, were measured and compared with that of stone and brick chips. Then the individual batches of concrete were produced using stone chips, brick chips, and iron slag with a mixing ratio of 1:1.5:3. Cylindrical specimens were produced and tested under compression up to failure. Results showed that concrete produced using brick chips as coarse aggregate yielded the lowest compressive strength compared to other concrete batches where stone chips and iron slag were used as coarse aggregate. Concrete using iron slag generates similar level of workability compared to the concrete produced using brick chips. Therefore, iron slag is expected to be preferred over brick chips as coarse aggregate in concrete production.

Keywords: Iron slag, brick chips, stone chips, concrete, compressive strength.

THE COMPREHENSIVE USES OF HOLLOW CONCRETE BLOCK IN BANGLADESH: PROSPECTS, CHALLENGES & ENVIRONMENTAL IMPACT

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Abstract: Hollow concrete blocks (HCB) have emerged as a viable alternative over traditional building materials like bricks as one of the most fundamental materials used in building & construction works worldwide. It is essential to construct walls, pavements, and other masonry work for building a durable & terminable structure. Nowadays, technological advancement upgraded with time demands a green, eco-friendly & sustainable world. HCB can play a significant role in that regard as it has superior thermal and fire resistance, higher strength, cost-effectiveness, and eco-friendly nature. But in Bangladesh, only a considerable amount of construction takes place using HCBs. But, with the advancement of sustainable structural technology, more frequent use of HCBs is essential. Therefore, this article briefly reviews the comprehensive uses of HCBs in Bangladesh with the manufacturing process to advantages and drawbacks. The article acknowledges that HCBs have lower water absorption, closer compressive strength, less unit weight, and higher fire resistance properties of HCBs than conventional bricks. It has also shed light on the positive environmental impacts as eco-friendly and cost-effective construction materials produce HCBs. Hence, this study reviews various properties and the way towards sustainability of using HCBs along with the challenges as well as way-out of challenges that come across its construction practices.

Keywords: Hollow Concrete Block, Advantages, Drawback, Environmental Impact, Bangladesh.

SHORT-TERM AND LONG-TERM AGING PERFORMANCE OF STYRENE BUTADIENE STYRENE (SBS) MODIFIED ASPHALT BINDER

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Abstract. The application of Styrene Butadiene Styrene (SBS) is now very popular in flexible pavement. Because of high latent and specific heat, it can effectively improve the physical and rheological properties of the conventional asphalt binder. This study evaluated the rheological properties of SBS-modified asphalt binder (PG 64-22) at short-term and long-term aging conditions with different dosages (2%, 4%, 6% by weight of base asphalt) of SBS. Rolling thin film oven test (RTFOT) and Pressure aging vessel (PAV) were applied for short-term and long-term conditions respectively. Then the impacts of each aging technique on the binders' rheological and physical properties were investigated. Four samples were put through penetration, softening, and viscosity tests for the investigation of physical properties performance and dynamic shear rheometer (DSR) test for the investigation of rheological properties performance. According to the findings, as compared to asphalt binder modified with 2% and 4% SBS, the asphalt binder modified with 6% SBS exhibits stronger retained penetration and softening as well as a lower viscosity aging index. From the rheological performance, 6% SBS-modified asphalt shows a bigger complex shear modulus (G*) and a smaller phase angle (δ) than the 2% and 4% SBS-modified asphalt binder. In conclusion, adding more percentage of SBS with asphalt binder increase the physical and rheological performance of base asphalt binder.

A DATABASE OF CONCRETE CORE TEST RESULTS AND COMPARATIVE ANALYSIS WITH ACI 562 GUIDELINES: INSIGHTS FOR STRUCTURAL ASSESSMENT

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Abstract. Core tests are typically conducted after construction to assess whether the hardened concrete in a new structure meets strength-based acceptance criteria. They can also be used to evaluate the strength of in-place concrete in an existing structure and determine its structural capacity. In recent years, numerous studies and procedures have been carried out to investigate the properties of concrete and its in situ conditions. In this particular study, 1608 core test data were collected from various locations throughout Dhaka, out of which 1428 relevant data were filtered based on a standard deviation greater than 15 and a number of samples greater than 1. Among the 1428 filtered data, 1285 represented horizontally collected samples (taken from beams, columns, and shear walls) and the remaining 143 represented vertically collected samples (taken from floors, raft or mat foundations). The data were analyzed based on the age of the structure, standard deviation, number of samples, core cutting direction, average compressive strength, and H/D ratio. To minimize the variation between the average concrete crushing strength and the equivalent concrete crushing strength, new coefficients were introduced. The study also made some observations by comparing the strength values of cores extracted from beam or column members. Finally, the study proposed new equations for determining the design strength to be used in the safety verifications required by structural codes for existing structures and compared them with the existing equations.

Keywords: Core tests, Hardened concrete, In-place concrete, Structural capacity, Concrete properties, Comparative analysis, Design strength.

REACTION DEGREE AND CHLORIDE BINDING IN SLAG BLENDS: INFLUENCE OF TEMPERATURE ON LOW WATER-TO-BINDER RATIO

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Abstract. Reinforced concrete structures exposed to seawater and de-icer environment are often suffering chloride attack and corrosion. Use of blast furnace slag as supplementary cementitious materials has been known beneficial for chloride resistance. However, the slag blended in Portland cement may exhibit different reactivity and characteristics of hydration product. Experimental study on reaction degree, compressive strength, and chloride binding were carried out for slag blends with OPC for four replacement levels (0%, 20%, 50% and 70%), two curing temperatures (20ºC and 40ºC) and w/b ratio 0.3. Compressive strength test was conducted on mortar specimens at 56 days. Paste samples were prepared and tested for reaction degree at 56 days and chloride binding at 186-days. Thermogravimetric analysis and selective dissolution were conducted to determine $Ca(OH)_2$ content and slag reaction, respectively. Hydrated samples were immersed in NaCl solution of varied concentrations from 0.1 to 3.0M and bound chloride at equilibrium was determined. From results, it was found that slag reactivity decreased with increasing replacement levels. Accelerating effect of high temperature on slag reaction was also confirmed. With increasing slag ratios and temperatures, compressive strength increased up to 50% slag blend. Slag blends were shown to be more effective than OPC in chloride binding, with 50% slag blends providing the highest results. For 50% slag blend, bound chloride increased by about 10% and 27% than OPC at 20°C and 40°C, respectively at free chloride concentration 3.0M. Increased chloride binding of slag compared to OPC was attributed to more hydration product of C-S-H and monosulfate in the paste.

STRENGTH BEHAVIOR OF GLASS FIBER REINFORCED CONCRETE WITH RECYCLED COARSE AGGREGATE

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Abstract. Concrete is the most used construction material in the world. But the major problem associated with the concrete is its poor performance under tension. It is well established that concrete's fragility in tension can be mitigated by adding fiber. Another engineering problem in the construction industry is the scarcity of the natural aggregates. This research study aimed to enhance the mechanical properties of concrete by incorporating glass fiber (GF) and simultaneously focused to examine the effects of replacing a portion of the natural coarse aggregate (NCA) with recycled coarse aggregate (RCA). 10- 25 mm length of GF was considered to use in 0%, 0.25%, 0.50% and 0.75% of total volume. RCA content was used as a partial replacement of NCA at 0%, 25% and 50% by weight. Flexural strength, split tensile strength, and flexural strength of Glass Fiber Reinforced Concrete (GFRC) with RCA was carried out to evaluate the mechanical properties. 25% RCA replacement with 0.50% GF (R25GF0.50) showed the best results, i.e., 4.16% increase in compressive strength, 8.70% increase in split tensile strength and 33.30% increase in flexural strength in comparison with the control mix (0% RCA, 0% GF). 50% RCA replacement with 0.5% GF showed 23.78% increase in flexural strength. However, it shows an insignificant increase (0.76%) in compressive strength and a decrease (2.17%) in split tensile strength.

Thus, the findings of this study are showed that RCA can easily be incorporated in concrete with GF for better mechanical performance. Additionally, the study of GFRC provides a visible solution to lessen the negative impacts of RCA on the mechanical strength of concrete, offering effective and environmentally friendly construction methods.

MECHANICAL PROPERTIES OF FIBER REINFORCED RUBBERIZED RECYCLED CONCRETE

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Abstract. Using sustainable green concrete in construction industries is getting popularity. Using recycled concrete and used tires as aggregates can be a sustainable future for the concrete industries. This study examines various mechanical characteristics of concrete with recycled coarse aggregate (RCA) produced from demolished concrete wastes, crumb rubber (CR), which comes from used car tires and polypropylene (PP) fiber. A total of five concrete mix ratios were selected varying the percentage of CR content at 0, 5, 10, and 15% with a fixed RCA level of 30% and PP fiber of 0.5%. The results were then compared to conventional concrete in terms of compressive strength, modulus of elasticity, tensile strength, flexural strength, and ultrasonic pulse velocity (UPV). Besides, a cost analysis had been conducted to promote this fiber reinforced rubberized recycled concrete (FR^3C) as a cost-effective, sustainable, and eco-friendly concrete. It was observed that the compressive strength of FR^3C decreased with an increase in the CR percentage. However, more than 40 MPa concrete can be produced by limiting the CR replacement level at 5%. Besides, a marginal reduction of only 3.3% and 6.8% was found in tensile and flexural strength for the specimens containing 5% CR content. In addition, the FR^3C mixtures demonstrated a higher energy saving compare to the conventional concrete.

Keywords: Fiber reinforced rubberized recycled concrete, compressive strength, tensile strength, ultrasonic pulse velocity, cost analysis.

EFFECTS OF WASTE PLASTIC BOTTLE STRIPS AS REINFORCEMENT ON THE ENGINEERING PROPERTIES OF SOIL FOR SUSTAINABLE SOIL STABILIZATION

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Abstract. Management of plastic waste has emerged as a critical global issue with significant environmental impacts. Recently, waste plastics have been utilized for sustainable soil stabilization techniques. This study presents an approach for using plastic waste as a reinforcing material for soil. The primary objective of this research is to investigate the impact of polyethylene terephthalate (PET) strips, randomly dispersed in lean clay soil (CL), on engineering properties. Laboratory experiments were conducted on soil samples mixed with varying contents (0 to 0.8%) of the rhombus (side length: 15 mm), equilateral triangle (side length: 15 mm) strips, and circle (diameter: 15mm). Test results indicate that adding up to 0.6% of PET strips led to a significant increase in the maximum dry unit weight, unconfined compression strength (UCS), and California Bearing Ratio (CBR) values. The enhancement of strength of soil reinforced with rhombus strips was more prominent than that of the soil reinforced with triangular strips. The findings of this study demonstrate that utilizing plastic waste as soil reinforcement in an appropriate manner can significantly improve the strength and bearing capacity, as well as modify soil properties. This technique may have important implications for sustainable waste management practices and soil engineering. In conclusion, the proposed technique of using plastic waste as a soil-reinforcing material represents a promising approach to address the growing challenges of plastic waste management, while also contributing to the improvement of soil properties.

Keywords: Sustainable soil stabilization, plastic waste, polyethylene terephthalate, soil reinforcement, strength enhancement.

INVESTIGATING THE COMPRESSIVE STRENGTH OF GREEN CONCRETE MADE WITH MULTIPLE TIMES RECYCLED AGGREGATES

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Abstract. Concrete recycling is a trendy subject matter in the field of sustainable construction. Several studies pointed to the beneficial application of aggregates obtained by recycling the demolished concrete. However, a major portion of the research conducted in this field is on first-generation recycled aggregates and green concrete made with them. The potential of green concrete made with recycled aggregates to be recycled again is yet to be evaluated. In the present approach, three generations of recycled aggregate and green concrete made with them are studied. Concrete blocks are collected from a demolished highway culvert and broken into standard aggregate sizes. Green concrete prepared using these recycled aggregates is named first-generation green concrete. After attaining sufficient strength, the first-generation green concrete is broken to produce aggregates which are said to be second-generation recycled aggregates and concrete made with them as second-generation green concrete. In a similar manner, third generation concrete specimens are produced. Lower compressive strength was encountered in successive higher generations of green concrete. A delayed strength-gaining was also observed for the green concrete indicating a prolonged curing requirement for them. At a longer curing period of 56 days, 1st and 2nd generation green concrete are found to meet the minimum strength requirements for C-25 concrete and for the 3rd generation green concrete the requirement can be met after 84 days of curing. The observations might be helpful in planning the usage of recycled aggregate in making green concrete.

Keywords: Green Concrete, Recycled Aggregate, RCA, Repeated Recycling.

EVALUATION OF POROUS CONCRETE FOR STRENGTH AND PERMEABILITY POLYPROPYLENE AND RECYCLED AGGREGATES TOWARDS URBAN SUSTAINABILITY IN DHAKA CITY

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Abstract. As a growing megacity, Dhaka is developing infrastructurally day by day resulting in the construction of new concrete paved open spaces. These pavements halt the infiltration of water into the ground and reduce groundwater recharge drastically affecting the scarcity of pure drinking water and settlement of the ground surface. To mitigate this problem porous concrete is a tremendous solution. In this research, we tried to evaluate different properties of porous concrete using different materials like plastic and recycled concrete aggregates. The study focuses on urban sustainability and resilience to vulnerabilities of water logging and other problems associated with it by ensuring the use of rubbish materials in the making of porous concrete. It also incorporates the change of porosity and compressive strength of porous concrete under the use of a super-plasticizer as an admixer. This research will help to understand the variation of properties for the porous concrete pavement with the use of different materials and ensures the use of plastic and recycled concrete along with superplasticizer as a sustainable solution for making porous concrete. It also opens the scope for further study of infiltration and consolidation control for the use of porous concrete as a pavement material.

Keywords: Porous concrete, compressive strength, urban sustainability, pavement materials, recycled concrete.

EFFECT OF PARTIAL REPLACEMENT OF FINE AGGREGATE BY TANNERY CRUMB ON MECHANICAL PROPERTIES OF CONCRETE

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Abstract. The leather industry is an essential contributor to Bangladesh's economy, but its by-product, tannery crumb, poses severe environmental and health risks due to heavy metal contamination. As such, there is a growing need to develop innovative solutions to manage tannery crumbs and reduce its impact. Therefore, an experimental program was conducted with a mix ratio of 1:1.5:3. The ingredients incorporated in this ratio were OPC cement, Sylhet sand with a fineness modulus of 3.1, and 19mm downgrade stone chips. The fine aggregate was replaced by volume with tannery crumb at varying percentages of 0%, 10%, 20%, and 30% by volume, while maintaining water-cement ratios of 0.40, 0.45, and 0.50, aimed to evaluate the effect of tannery crumb on the mechanical properties of concrete, including compressive strength (f_c') splitting tensile strength (f_t), and flexural strength (f_r). The maximum compressive strength was found at 20% tannery crumb with a water-cement ratio of 0.40, resulting in 45.56 MPa and 54.15 MPa at 28 and 90 days, respectively. The maximum splitting tensile strength was found at 20% tannery crumb with a water-cement ratio of 0.45, resulting in 3.23 MPa but strength was 3.12 MPa at a w/c ratio of 0.40 showing a very slight difference. However, the flexural strength decreased with an increase in the tannery crumb and water-cement ratio. The load-deflection curve obtained from the flexural strength test revealed a sudden failure behavior, with no signs of improvement in its inherent brittle behavior. Anyway, all the experimental data from flexural and compressive strength fell within the ACI-mentioned range of 7.5 to $12\sqrt{f_c'}$.

Keywords: Leather industry, Tannery Crumb, Heavy metal, Concrete, Compressive Strength, Splitting Tensile Strength, Flexural Strength.

INVESTIGATION ON BOND STRENGTH OF RECYCLED AGGREGATE CONCRETE USING CRUMB RUBBER AND POLYPROPYLENE FIBER AS PARTIAL REPLACEMENTS FOR CONVENTIONAL CONSTRUCTION MATERIALS

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Abstract. In the era of rapid technological progress, managing construction and demolition wastes poses challenges to achieving sustainable development goals. This research explores using recycled coarse aggregate (RCA) and waste materials like crumb rubber (CR) for construction. By combining these materials with polypropylene fiber (PPF), a new approach is proposed to promote green construction practices. The study analyzes the bond strength of concrete with RCA, CR, and PPF, replacing portions of natural coarse and fine aggregates. This research utilized the pull-out method for observing and analyzing the bond strength performance of concrete consisting of RCA, CR, and PPF. Natural coarse aggregate (NCA), natural fine aggregate (NFA), and cement were partially replaced by recycled coarse aggregate (10 and 30%) on a weight basis, crumb rubber (5 and 10%) on a volume basis, and polypropylene fiber (2%) on volume basis respectively. Different steel reinforcement lengths and diameters are tested. It is recommended that the replacement of 30% NCA with RCA and 2% cement with PPF without replacing NFA by CR can be executed in construction without compromising the safe margin of concrete bond strength. This research encourages sustainable development and the use of recycled materials in construction.

UTILIZATION OF GGBS, FLY ASH, AND RECYCLED AGGREGATES FOR SUSTAINABLE GEOPOLYMER CONCRETE: A CARBON REDUCTION APPROACH

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Abstract. Cement production contributes significantly to greenhouse gas emissions, highlighting the need for sustainable alternatives. Geopolymer concrete (GPC) offers a lower carbon footprint and serves as a promising substitute for traditional cement-based concrete. This study investigated the use of fly ash, ground granulated blast furnace slag (GGBS), recycled coarse aggregate, alkaline solutions (sodium silicate and sodium hydroxide), and fine aggregate to make GPC. Varying percentages (each ranging from 10% to 100%) of fly ash and GGBS, different molarities (6M, 10M, and 14M) of sodium hydroxide, and different ratios (1.5, 2.0, 2.5, and 3.0) of sodium silicate to sodium hydroxide were examined to determine the optimal combination for strength and durability of GPC. Two curing methods, ambient curing and membrane curing, were employed. The results showed that increasing the percentage (from 0% to 100%) of GGBS in the mix led to a higher compressive strength of 4122 psi and a lower water absorption of 4.83% at day 28. GGBS as the sole binder exhibited the highest strength and durability, and GPC with a 50% GGBS-50% fly ash composition outperformed conventional cement concrete. Membrane curing consistently yielded higher compressive strength compared to ambient curing. The study concluded that GGBS-fly ash-based recycled aggregate GPC could significantly reduce waste and the carbon footprint in the construction industry.

Keywords: Fly ash, Ground granulated blast furnace slag (GGBS), Ambient

EFFECT OF GALVANIZED IRON FIBER ON BOND STRENGTH OF RECYCLED AGGREGATE CONCRETE

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Abstract. Recycled coarse aggregate (RCA) is being encouraged to use in concrete to protect natural resources and manage structural demolition debris. On the other hand, a strong bond between concrete and reinforcing bars ensures the safety and durability of any structure. However, recycled aggregate concrete (RAC) has relatively inferior properties to natural aggregate concrete (NAC), which can be mitigated through fiber application. Thus, this study investigates the mechanical properties and bond behavior of galvanized iron fiber (GIF) reinforced recycled aggregate concrete. Variables in this study are the percentages of GIF (0%, 0.25%, and 0.5%), rebars of diameter (D) variations (16 mm and 20 mm), and the embedded lengths (8D and 12D). Two variations of RCA are used, 0% and 50%. The results disclose that the mechanical properties deteriorate with increasing RCA. On the other hand, the use of GIF has a favorable impact on these properties. While compressive strength exhibits no direct relation with the amount of GIF, tensile strength shows a proportional relation. GIF increases the bond strength by up to 46%, especially with 0.25% GIF. Cylindrical specimens reinforced with 16 mm bars having embedded lengths of 8D demonstrate pull-out failure. For the other cases, the failure is mostly concrete. This study will decisively promote using RCA and GIF to improve the bond between concrete and rebars.

Keywords: Galvanized iron fiber, recycled coarse aggregate, bond strength, compressive strength, tensile strength.

SHEAR BEHAVIOR OF REINFORCED CONCRETE BEAM WITH PARTIALLY REPLACED RECYCLED AGGREGATE

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Abstract. The demolition of many concrete structures worldwide produces substantial waste, posing a significant environmental concern. Using this waste as recycled aggregate (RA) in fresh concrete can give a feasible solution to this problem. However, the inclusion of RA in concrete has challenges, especially in designing the shear capacity of beams. Therefore, this study investigates the effect of RA replacement percentage on the shear capacity of reinforced concrete beams. Three variations of RA replacement percentages (0%, 30%, and 50%) are considered to conduct the study. The shear capacity of the beams has been tested using a four-point loading test after 56 days of casting. According to the test result, the shear capacity of the beam improves for 30% replacement of RA by about 6% to 35%, which is significant. Further addition of RA causes a reduction of shear capacity. Replacing the natural aggregate with RA allows the beam to withstand more load against strain than the control concrete, indicating improved ductility in the beam. The maximum improvement in ductility is found with a 30% replacement of the RA.

Keywords: Reinforced Concrete Beam, Shear Capacity, Recycled Aggregate, Shear Span, Failure Pattern.

A REVIEW OF THE EFFECT OF FLY ASH ON DURABILITY PROPERTIES OF FIBER REINFORCED CONCRETE

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Abstract. Fiber-reinforced concrete (FRC) is already proving to be an efficient and better alternative to conventional reinforced cement concrete. It improves concrete properties like high compressive strength, flexural strength, tensile strength, ductility, toughness, energy absorption capacity, and electrical conductivity. It reduces waste generation by a considerable margin which can be considered green and sustainable environmental development. Various supplemental cementitious materials can be infused into FRC, including silica fume, fly ash, slag, etc. This research will discuss the durability property improvement of FRC created by fly ash. Several studies have already revealed fly ash's significant benefits on the durability of FRC's behavior. Fly ash incorporation reduces CO_2 emissions in concrete production and improves the sustainability of FRC. Because fly ash is a byproduct of coal-fired power plants, using it as a supplementary cementing ingredient is also cost-effective. Although the pozzolanic reaction caused by adding fly ash results in low early strength, fly ash shows higher strength at a later age. Fly ash reduces drying shrinkage and porosity. In this way, it also lowers sorptivity and chloride permeability. In general, the fractional replacement of fly ash in cement increases the durability of FRC.

Keywords: Fiber-reinforced concrete (FRC), fly ash, cementitious material, durability, cost-effective

MECHANICAL AND DURABILITY PROPERTIES OF INDUCTION FURNACE SLAG AND RECYCLED AGGREGATE CONCRETE

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Abstract. Cement manufacturing uses a lot of energy and is detrimental to the environment since it produces carbon dioxide. A large amount of demolition waste is being dumped into landfills daily, which is harmful to the environment. Induction furnace slag (IFS) is a byproduct produced vastly by steel industries. Hence, adopting recycled coarse aggregate (RCA) instead of natural coarse aggregate (NCA) and reducing cement by IFS can provide an environmentally friendly alternative to construction materials. Therefore, this study evaluates the mechanical properties of concrete that are partially blended with IFS and RCA. Compressive strength, splitting tensile strength, flexural strength and water absorption capacity of concrete are assessed to comprehend the combined behaviour of RCA and IFS. In this study, 10% and 20% of cement are substituted by IFS, and 25% of RCA has taken the place of NCA. The concrete workability improved with the addition of IFS but decreased for RCA. The compressive strength rose 10.2% when 25% RCA and 10% IFS were used. All the IFS concretes exhibited a greater splitting tensile strength of up to 24.2% and flexural strength of up to 39.1%, depending on the percentage of IFS and inclusion of RCA. The water absorption capacity decreased with increasing the percentage of IFS content, but adding RCA content increased it. According to the findings, using 25% RCA and 10% slag can be an effective approach for concrete.

Keywords: Induction furnace slag, recycled coarse aggregate, workability, compressive strength, tensile strength, flexural strength.

APPLIED MACHINE LEARNING IN CRUMB RUBBER AND RECYCLED AGGREGATE CONCRETE: A REVIEW

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Abstract. In recent years, there has been a growing challenge to decreasing the environmental impact of waste concrete in the construction industry. Recycled aggregate concrete and crumb rubber concrete have emerged as popular alternatives to traditional concrete due to their potential to reduce the excessive usage of cement in concrete mixtures. Cement is a high-priced chemical substance that has detrimental effects on the environment, mainly due to the carbon dioxide emissions associated with its production. The cement industry currently accounts for 5–10% of global anthropogenic CO2 emissions, and the production process requires high levels of energy consumption. While improving manufacturing technologies can reduce emissions, using alternative materials is increasingly recognized as a more accessible and sustainable approach. By using crumb rubber as a replacement for coarse aggregate materials and combining recycled aggregate with superplasticizers, it would be possible to produce high-quality concrete with reduced cement usage. This can not only improve the compressive strength and durability of the resulting material but also make it more environmentally friendly. However, determining the compressive strength of concrete can be a time-consuming and expensive process. To address this issue, accurate machine learning models have been developed to predict the compressive strength of concrete based on its mixture proportions. This paper reviews various methods for incorporating recycled aggregate and crumb rubber into concrete, along with the machine learning and statistical approaches used in the literature to estimate the mechanical properties of the resulting materials.

Keywords: Concrete, crumb rubber, recycled aggregate, compressive strength, environmentally friendly, CO2 emissions, machine learning.

EFFECT OF SOURCE OF RECYCLED AGGREGATE ON CONCRETE PROPERTIES - A CASE STUDY

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Abstract. Nowadays, one of the major issues facing societies is the rapid production of waste output, particularly construction trash. For a variety of causes, concrete buildings are destroyed, which results in rising waste production. This research project focused on the possibility of using recycled aggregate as a substitute for natural aggregate. The effects of three types of aggregate (vey old recycled aggregate aged 50 years, relatively new recycled aggregate aged 10 years & new fresh aggregate) on concretes in terms of their compressive strength, rapid chloride permeability, and rate of water absorption were studied. By following ASTM standards, tests such as sieve analysis, bulk specific gravity, water absorption capacity, and slump test were also conducted. It was observed that concrete made with very (~50 years) old recycled aggregate gave the highest compressive strength in comparison to those of relatively new aggregate (~10 years old) and new aggregate. For example, the 28-day compressive strength of concrete with very old (~50 years) aggregate was 47% higher than that of fresh aggregate. Test results also demonstrated that, concrete made with new aggregate had higher absorption capacity in contrast to that of recycled aggregates. It was observed that concrete made with all of these three types of aggregate had no significant difference in terms of chloride ion penetrability. This experimental study indicates that recycled aggregate sourced from very old structures may also be a promising alternative as aggregate for use in concrete.

Keywords: Recycle aggregate, old aggregate, compressive strength, rapid chloride permeability.

PROPERTIES OF SUSTAINABLE CONCRETE MADE FROM RECYCLE PLASTIC AND DEMOLISHED CONCRETE AGGREGATES

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Abstract. As the world population rises, different types of waste are being created. The creation of non-decaying and low bio-degradable waste materials, combined with a growing consumer population has resulted in a waste disposal crisis. One solution to this crisis is recycling waste into useful products. Waste such as demolished concrete and plastics are non-degradable materials most of the produced are dumped into the environment. However, due to the environmental pollution as well as the high energy-demand associated with the production of construction materials, researchers are investigating the possibility of using different waste aggregates in the production of concrete. For this purpose, in this study the conventional coarse aggregates of concrete are replaced by the waste plastic and recycle of demolished concrete aggregates up to a level of minimum 5% to 20%. The concrete cylinders are casted and tested for compressive and split tensile strength after a curing period of 7, 14 and 28 days. The results indicate that the strength of concrete decreases as the percentage of waste aggregates increases. However, 10% aggregate replacement still seems acceptable as in the replacement level, the strength reduction is relatively low. Water absorption and total pores percentages in the concrete samples for all mixes are also investigated. Different relations among the obtained results are also developed for the prediction of concrete properties using waste aggregates. Successful application of appropriate amounts of waste aggregates can not only reduce the cost of concrete but could also preserve the environment.

Keywords: Plastic Aggregates, Recycled Concrete, Mechanical Strength, Water Absorption, Pore Volume.

COMPARATIVE STUDY ON PROPERTIES OF SELF-COMPACTING CONCRETE MADE WITH RECYCLED AGGREGATE

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Abstract: Use of self-compacting concrete (SCC) is gaining popularity around the world as mechanical vibration isn't required for compaction. To provide accumulation for the increasing population, demolition of old structures are producing a huge amount of crushed concrete wastes. To construct environment-friendly structures with reasonable cost and available resources, these wastes can be recycled in various ways, such as aggregates. This paper represents the comparison of properties of SCC by recycling crushed pile head concrete as a replacement of natural coarse aggregates (NCA) for different percentages (0% and 20%) using 10-12mm and 10-20mm sized recycled coarse aggregates (RCA). The properties of SCC are self-passing ability, workability and filling ability in congested reinforcement without segregation, providing the required strength. These properties depend on the particle size and amount of recycled waste aggregates, the water-cement ratio, influence of old mortar etc. In this research, the workability was tested by using the slump flow test method, L-box test method and V-Funnel test method. For measuring strengths, compressive strength and splitting tensile strength test method were adopted. The test results show that increasing the amount of RCA instead of NCA made the system less workable and reduced strength of SCC. Also using smaller sized RCA improved workability and strength characteristics than larger sized RCA. After 28 days, the cases of SCC were tested to see how strong they were.

Keywords: Self-compacting concrete, recycled coarse aggregate, crushed pile head concrete, old mortar

A REVIEW ON THE PERFORMANCE OF RAP BINDER REJUVENATED WITH VARIOUS WASTE OILS

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Abstract. Approximately 110 million tons of bitumen are utilized every year in the global highway industry. Recycled asphalt pavement (RAP) binder has to be used to build roads so that less pressure is put on the natural supply of asphalt. Nonetheless, a significant challenge of using RAP binder is that it increases the stiffness of the mixture, which can lead to fatigue and low-temperature cracking over the course of its service life. The use of rejuvenators has been suggested as a possible way to deal with this problem. The use of rejuvenators can modify the asphaltene to maltene ratio in the RAP binder, which improves the viscoelastic and rheological properties of the aged binder. Recent studies have shown that various types of waste oils, such as waste engine oil, waste vegetable oil, tall oils, and bio-oil, can be used as rejuvenators to make RAP binders as good as virgin binders. Overall, using RAP with rejuvenators could change the way roads are constructed and help developing countries like Bangladesh become more environmentally friendly. This review paper provides a comprehensive overview of aged RAP binders, to assess their performance with varying rejuvenators in the pavement.

Keywords: Reclaimed Asphalt Pavement (RAP), Aged Bitumen, Rejuvenator, Viscoelastic Properties, Rheological Properties.

NUMERICAL SIMULATIONS OF RACFST COLUMNS UNDER CONCENTRIC AXIAL LOAD

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Abstract. Recycled aggregate concrete (RAC) is both economical in construction and eco-friendly in waste disposal. Nowadays recycled aggregate concrete filled steel tubular (RACFST) column is getting popularity. As it is a recent innovation, there are many scopes of improvement in the design guidelines of RACFST column. This study presents numerical simulations of RACFST columns under concentric axial load. A 3D nonlinear finite element (FE) model is developed using ABAQUS software. Both geometric and material nonlinearity are included in the developed model. A concrete damage plasticity model is used to track the nonlinear behavior of concrete. The FE model is validated using experimental results available in the literature. The model is found to be capable of successfully tracing the load-deformation behavior and failure mode observed in the reference tests. Comparisons are made among the specimens with variable parameters including RAC ratio, steel percentage, and slenderness of the steel tube. Results predicted by the model are similar to the test results. Steel percentage and RAC replacement ratio show the most and the least significant influence on the load carrying capacity, respectively. In addition, individual contribution of steel and concrete is determined.

Keywords: Recycled aggregate concrete, composite column, finite element, nonlinear, numerical.

OPTIMIZATION OF SILICA-FUME AND FUMED SILICA CONTENT IN HIGH-STRENGTH CONCRETE

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Abstract. This study aimed to optimize the content of silica fume and fumed silica in high-strength concrete (HSC) with varying water-binder ratios (W/B) through a series of experimental investigations. It involves the formulation of HSC mixtures having a W/B ratio of 0.32 and by replacing cement with varying percentages of silica fume and fumed silica. A total of 120 cubes of concrete specimens with dimensions (100 mm × 100 mm × 100 mm) were fabricated with different mix proportions of concrete. The compressive strength of the HSC samples was evaluated at 7, 28 and 56 days. The results showed that the incorporation of silica fume and fumed silica significantly reduced the workability of the high-strength concrete. The highest compressive strength was achieved at 7.5% silica fume and 2.5% fumed silica content. This study provides useful information for optimizing the use of silica fume and fumed silica in HSC for 0.32 W/B ratio, which can lead to more sustainable and durable concrete structures.

Keywords: High-strength concrete, silica fume, fumed silica, water-binder ratio, compressive strength.

ASSESSMENT OF BLENDED CEMENT MORTAR WITH FLY ASH AND LIMESTONE POWDER

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Abstract. Cement production significantly contributes to greenhouse gas emissions, and modern times call for alternative binding materials. Blended cement combined with class F fly ash (FF) and limestone powder (LP) can reduce the environmental impact of cement production. In this study, mortar cubes are made by replacing cement with 15% FF (CFM), 10% LP (CLM), and a combination of 10% FF and 5% LP (CFLM). The mix proportions are based on the particle packing or dense pack method. Tests are conducted to ascertain blended mortars' mechanical and durability properties compared to regular cement mortars. When both FF and LP are added to the mortar, the compressive strength decreases by 24% compared to the control mix after 56 days. Though CLM produces high early strength, CFM shows high strength in later days. The durability test conducted at 400℃ and 600℃ temperatures shows that the compressive strength increases up to 16%, while CFM performs better than CLM under elevated temperatures. The shrinkage test shows that the mortar samples with FF and LP replacement exhibit a 23% lower shrinkage value than the control specimen. FF increases later strength gain, while LP performs better in shrinkage. The findings suggest that combining FF and LP in blended cement significantly impacts mortar's mechanical and durability properties.

Keywords: Fly Ash, Limestone Powder, Blended Cement Mortar, Dense Pack, Compressive Strength, High Temperature, Shrinkage.

WOOD ASH-BASED LOW-CARBON CEMENTITIOUS COMPOSITES

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Abstract. Concrete is a huge emitter of CO_2. About 900 kg of CO_2 is emitted to produce 1000 kg of cement, concrete's main ingredient. To reduce the carbon footprint of cement, supplementary cementitious materials (SCM) are adopted as a partial replacement. Coal fly ash is a popularly used SCM to replace cement in concrete; however, coal industries being shut down globally because of the negative environmental impact results in the scarcity of coal fly ash. Wood ash, which is generously produced in the timber-based construction industry of western Canada as a byproduct of bioenergy, can be a potential substitute for coal fly ash. Including wood ash in concrete solves the disposal issue of the abundant wood ash produced as well. This study evaluates the performance of wood ash-based cementitious composites considering their compressive strength and setting time results. There are two types of ash produced from burning wood, wood fly ash (WFA) and wood bottom ash (WBA). Being the finer ash, WFA replaced cement, and the coarser WBA replaced sand at 15, 30, 45%, and 15, 30% levels, respectively. It was observed that the combination of 15% WFA and 15% WBA provided a comparable result with the reference mortar based on the compressive strength.

INVESTIGATION ON MECHANICAL AND DURABILITY PROPERTIES OF LEAD-ACID BATTERY REFINERY RESIDUE BASED CONCRETE

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Abstract. The increasing demand of lead-acid batteries as a temporary source of electricity in developing countries has led to the production of large amounts of lead-acid battery refinery residue (LABRR) which is not only hazardous to the environment but also very difficult and expensive to properly dispose. This research work aims to disclose the optimization of a new material incorporated in concrete. A comprehensive study on the physical, mechanical and durability properties of concrete materials containing LABRR as partial replacement of cement and its comparison with common cementitious concrete is presented in this research work. Six batches of concrete were prepared with varying content of LABRR (0%, 10%, 15%, 20%, 25%, 30%) as partial replacement of ordinary portland cement. The selected mixing ratio was 1:1.5:3 with a constant w/c of 0.45. The compressive and tensile strength (28 days) of 20.5 MPa and 2.4 MPa, respectively were achieved for the concrete mix containing 20% LABRR whıch was close to that of control specimens. It also exhibits the maximum unit weight of 24.7 kN/m^3. The compressive and tensile strength decrease rapidly beyond this percentage. The water permeability test also revealed that the 20% replacement LABRR concrete displayed the optimum performance against water permeability indicating more durable concrete.

Keywords: Lead-acid battery refinery residue (LABRR), ordinary portland cement, compressive strength, tensile strength, durability.

MECHANICAL BEHAVIOR OF CONCRETE INCORPORATING RECYCLED STEEL AND POLYPROPYLENE FIBERS: EXPERIMENTAL INVESTIGATION

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Abstract. Concrete is presently the utmost extensively utilized construction material as a consequence of its conventional casting to any configuration and shape at the site. As fibers be able to premix in a conservative way, the perception of steel and polypropylene fibers in concrete has introduced an additional aspect in concrete construction. This research presents the experimental studies for investigating the influence of recycled steel fibers (RSF) and recycled polypropylene fibers (RPF) on the physical as well as mechanical performance of concrete. Recycled steel and polypropylene fibers were incorporated in a variety of percentages, i.e. 0.5%, 1%, 1.5% and 2% by volume of concrete, along with control specimen, i.e. plain concrete. The physical properties of all constituent materials, steel as well as polypropylene fibers, have been determined. The workability of fresh concrete for each batch of concrete has also been assessed through a slump test. A significant number of cylindrical specimens were cast. The experimental program comprises of splitting tensile strength test, compressive strength test, modulus of elasticity and Poisson's ratio test on concrete incorporating RSF and RPF. The stress-strain performance of both recycled steel and polypropylene fiber concrete has also been illustrated in this research. Based on the experimental investigations, it can be disclosed that the workability of concrete declines gradually with the intensification of the addition of fibers. However, there is a significant enhance in tensile strength, compressive strength as well as modulus of elasticity of recycled steel fibers concrete, followed by recycled polypropylene fibers concrete. Furthermore, the integration of RSF and RPF increases the stiffness of concrete in addition to make the concrete quite ductile.

Keywords: Steel fiber, polypropylene fiber; workability, compressive strength, tensile strength, ductile.

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STRENGTH DEVELOPMENT OF ARTIFICIAL AGGREGATE MANUFACTURED FROM GEOPOLYMERIZATION OF WASTE MATERIALS

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Abstract. The rapid expansion of the construction industry globally has precipitated an increased need for construction materials to accommodate the development of new infrastructures. Unfortunately, this surge in construction activities has resulted in detrimental consequences for the environment. The depletion of natural aggregates has led to attempts to explore the use of waste materials to produce artificial aggregates. Waste minimization and recycling have also become crucial issues in the 21st century. This study focuses on the potential of using waste materials, such as sewage sludge ash (SSA), medical waste incineration ash (MWIA), and coal-based fly ash (CFA), to produce artificial aggregates through geopolymerization. The study utilized three combinations of these materials activated with sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). The resulting samples were compacted by auto compaction, cured for 28 days with an initial 24-hour heat cure, then manually crushed to produce aggregates. The characteristics of the resulting aggregates were evaluated through various tests including specific gravity, water absorption, aggregate impact value, and crushing index. The study found that the sample with a ratio of MWIA:SSA:CFA of 1:1:1 demonstrated the highest crushing index, which was 97% higher than the brick chips used as the control specimen. The sample with a ratio of MWIA:SSA:CFA of 1:1:0 performed better in terms of engineering properties, with the lowest aggregate impact value and the lowest water absorption. The findings of this study suggest that utilizing waste materials to produce artificial aggregates could be a sustainable and eco-friendly way to replace natural aggregates in construction projects.

Keywords: Artificial aggregate, geopolymerization, sewage sludge ash, medical waste incineration ash, coal-based fly ash.

STRENGTH AND WORKABILITY OF CONCRETE INCORPORATING VOLCANIC ASH AS A PARTIAL REPLACEMENT FOR CEMENT

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Abstract. The use of volcanic ash as a partial replacement for cement in concrete mix is explored in this study. The objective of the research was to determine the strength and workability of volcanic ash-based concrete. The parameter of the study was the amount of volcanic ash (0% - control, 15%, 25%, and 35%) used as a replacement for cement. Compressive strength tests of concrete were performed at 7, 14, 28, and 56 days. Test results indicate that with 15% replacement of cement with volcanic ash achieved 90% of the compressive strength of concrete with no volcanic ash after 28 days with almost 75% of strength gain occurring in 7 days. Concrete with 25% and 35% replacement of cement with volcanic ash achieved 80% and 77% strength of the control specimen, respectively. Concrete incorporating volcanic ash as a partial replacement for cement exhibited sustained gain in compressive strength even after 28 days. Specifically, concrete prepared with a 15% volcanic ash replacement achieved higher compressive strength at 56 days compared to concrete with no volcanic ash. On the other hand, the workability of concrete decreased as the percentage of volcanic ash increased. However, it is noteworthy that the concrete with a 15% volcanic ash replacement demonstrated almost similar workability performance to conventional concrete. The study suggests that incorporating volcanic ash as a partial replacement for cement can be a viable option to reduce the negative environmental impact of cement production.

Keywords: Volcanic ash, concrete, compressive strength, workability, mix design, sustainability.

INFLUENCE OF RECYCLED COARSE AGGREGATE ON PHYSICAL AND MECHANICAL PROPERTIES OF CONCRETE

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Abstract. With the passage of time, increasing number of aged concrete structures are becoming burden on the modern world. A proper disposal of construction and demolition wastes is one of the main environmental challenges in the construction arena. Hence, reusing and recycling can be the best sustainable option dealing with the construction and demolition wastes. Bangladesh being a developing country sees a greater volume of concrete construction. Most aggregate used in the construction industry within the country is imported due to the scarcity of natural resources. The use of recycled materials during construction would have a significant environmental and economic impact. This paper presents a study on the effect of using recycled coarse aggregate on some physical and mechanical properties of concrete. Recycled coarse aggregate (RCA) was prepared from the laboratory waste of concrete samples disposed after routine tests. The RCA replacement of 0%, 25%, 50% and 75% were used in the study. A decrease in specific gravity and a high affinity for water absorption was observed with the increased percentage of recycled aggregate content in the concrete. The mechanical properties of concrete were compared with regard to the compressive strength, splitting tensile strength and shear strength. The results indicated a gradual decrease in the strength properties of concrete with increasing % RCA in concrete. Microstructural properties of aggregate play an important role in controlling the physical and mechanical properties of concrete with RCA.

Keywords: Construction, Concrete, Recycled Aggregate, Concrete Properties, Strength.

ANALYSIS OF RECYCLING OF STEEL SLAG AS CONSTRUCTION MATERIAL

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Abstract. Steel slag is a by-product of steel melting process which poses threat to environment when dumped in land or waterbodies, on the other hand steel slag emerged as a suitable construction material in advanced sustainable environment friendly practice. Bangladesh is undergoing enormous infrastructural development and in need of good quality aggregates. The large quantity of steel slag produced from induction furnace of steel manufacturing plants in Bangladesh can fulfill the demand of aggregates. Induction furnace slag can be an excellent alternative to expensive imported stone chips and conventional brick chips coming from Hoffman kiln which pollutes environment severely. This review paper mainly focuses on recycle and re-use steel slag as an alternative solution which can reduce environment pollution significantly. This paper discusses the international use of slag and the challenges of utilizing steel slag as a recycled aggregate with recommendation to minimize the challenges.

Keywords: Steel slag, induction furnace slag, dumping, environment pollution, stone chips, brick chips, recycled aggregate.

COMPARING MANUAL VS. SPREADSHEET DESIGN FOR BUILDING SHORE PROTECTION SHEET PILE

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Abstract. Dhaka City engineers face challenges in constructing high-rise buildings by employing deep excavation without causing damage to adjacent structures. In this case, temporary shore sheet piling is frequently used to safeguard these buildings while they are under construction. The manual sheet pile design process is time-consuming and difficult to use in emergencies. To address these challenges, this paper proposes the use of an excel-based spreadsheet for shore protection pile depth estimation instead of manual design. The trial-and-error method considers different types of soil conditions, soil properties, water table levels, and adjacent structural loads. Field trials were done at Mohammadpur, Dhaka, to test the design's efficiency. The results indicated that the calculated pile depth using the excel-based spreadsheet was 8.1% higher than the manual design. This suggests that the excel-based spreadsheet approach provides a more sophisticated and safe design, considering the various factors involved. The excel-based spreadsheet design process saves engineers time by eliminating trial-and-error iterations and enabling quick estimation of embedded depth for shore protection piles. This efficiency is especially valuable in urgent situations where timely decision-making is crucial. The comprehensive and reliable analysis considers various factors affecting pile depth, aiding engineers and authorities in making informed decisions regarding temporary building shore protection.

Keywords: Dhaka city, building shore protection, sheet pile, manual design, spreadsheet design.

OPTIMIZING RELIABILITY ANALYSIS OF CONCRETE DAMS: A SPREADSHEET-BASED APPROACH

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Abstract. This research paper introduces a unique and efficient spreadsheet-based approach to enhance the reliability analysis of concrete dams. Conventional design approaches often neglect uncertainties in governing variables and rely on conservative assumptions, resulting in deterministic analyses that may not accurately capture dam behavior. By integrating probabilistic methods, specifically the First-Order Reliability Method (FORM), the proposed approach overcomes these limitations and provides a more accurate assessment. Using the FORM, this approach evaluates the probability of failure and safety index against sliding failures in gravity dams. The study focuses on the influence of dam height and slope on the safety factor and reliability index. Findings indicate that increasing dam height or steepening the slope at a constant height leads to a decrease in the safety factor and reliability index. Additionally, the downstream slope of earth core rockfill dams emerges as the critical failure mode, exhibiting lower safety factors and reliability indexes compared to the upstream slope. The introduced spreadsheet-based approach offers several advantages, including user-friendliness, flexibility, and improved computational efficiency. By utilizing commonly available spreadsheet software, engineers can optimize the reliability analysis process for concrete dams while considering uncertainties in governing variables. This research significantly contributes to advancing reliability analysis techniques for concrete dams. The novel spreadsheet-based approach provides a practical and effective means of enhancing reliability analysis, empowering engineers to make informed decisions regarding dam design, operation, and maintenance. Ultimately, this approach improves the safety and reliability of concrete dams, ensuring their sustainable performance across various water management applications.

Keywords: Dams, Concrete dams, Reliability index, Safety, First-Order Reliability Method (FORM).

NUMERICAL MODELING OF MUMBAI MARINE CLAY IMPROVED WITH PREFABRICATED VERTICAL DRAIN

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Abstract. This study presents a numerical modeling of marine clay improved by pre-fabricated vertical drains (PVD). PVDs have been installed at 1.2 m c/c in triangular pattern to 12 m depth. The height of preloading is 4.3 m. Harden-ing soil model has been employed to simulate the behavior of the in the PLAXIS 2D v21. The inputs of this constitutive model have been derived from well-established laboratory tests and correlations based on natural moisture content. Smear zone two and half times the equivalent diameter of the PVD has been considered. The numerical model is calibrated with field settlements through modification of only the vertical permeability. The predicted settlement agreed well with the measured one. But the excess pore pressure and lateral displacements predicted show some differences. The contributing factors for these discrepancies have been discussed. This study reveals that the natural moisture content is a reliable parameter for assessing the soft soil behavior.

Keywords: Soft soil, PLAXIS, Consolidation, FEM, Settlement.

DISCREPANCIES BETWEEN AUTOMATIC TRIP HAMMER AND DONUT HAMMER IN STANDARD PENETRATION TEST ON BANGLADESH PERSPECTIVE

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Abstract. The Standard Penetration Test (SPT) is one of the most popular field tests in sub-soil investigation techniques since a long ago. It is admired due to its simplicity and ease of operation. In spite of its a lot of advantages, geotechnical engineers had to face different types of discrepancies among SPT (N) values even if the soil parameters are reasonably similar. These dissimilarities are generally considered to be the major consequence of test assembly and the hammer energy transferred during Standard Penetration Test. Although a large number of efforts have been made to standardize the SPT procedure and resolve these variants, this test remains unpredictable due to the irregularities of variable parameters. This paper has been prepared as an initiative to reveal the discrepancies between the use of automatic trip hammer and donut hammer in Standard Penetration Test in Bangladesh perspectives. In this study, the Standard Penetration Tests are carried out in the same soil strata by using the automatic trip hammer and the donut hammer as well. It is observed that the SPT values obtained from donut hammer is significantly larger than the values obtained from automatic trip hammer which is nearly around 1.5 times.

Keywords: Standard Penetration Test, Automatic Trip Hammer, Donut Hammer, Hammer Energy, N-values.

EFFECTS OF NONPLASTIC SILTS ON ENGINEERING PROPERTIES OF SANDS

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Abstract. This study investigates the effects of nonplastic silts on the engineering properties of sands, focusing on grain size distribution, minimum and maximum dry density, optimum moisture content, permeability, and shear strength. Laboratory tests were performed on sand-silt mixtures with varying proportions by weight (0 to 60%) of nonplastic silts. Test results show that adding nonplastic silts to sands led to an increase in maximum dry density up to a silt content of 60%, after which the maximum dry density decreases. A continuous reduction of optimum moisture content was observed with increasing silt content. Moreover, the addition of nonplastic silts reduces the minimum dry densities of the mixtures. Limiting Fine Content (LFC) of 32% was found to be a crucial factor in understanding how sand-silt mixtures behaved. The permeability of sand-silt mixtures continuously decreased with the increase of nonplastic silts up to the LFC, after which the permeability became nearly constant. The drained shear strength (angle of internal friction) of the sand-silt mixtures having the same initial dry density continuously decreased with the increase of nonplastic silts. The findings of this study have significant implications for civil engineering design and construction, notably in soil stabilization and foundation design. This study emphasizes the importance of considering the impacts of nonplastic silts on the engineering properties of sands to ensure the safety and stability of structures.

Keywords: Nonplastic silts, sands, limiting fine content, compaction properties, permeability, shear strength.

DETERMINATION OF FLOW LINE SLOPE FOR ONE-POINT LIQUID LIMIT TEST OF FINE-GRAINED SOILS IN BANGLADESH

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Abstract. Atterberg limits are measures of critical water contents of fine-grained soils indicating the transition between solid, semi-solid, plastic, and liquid states. Liquid limit and plastic limit are widely used parameters to characterize various engineering properties of cohesive soils. Although the multipoint method of determining the liquid limit is preferable to engineers, the one-point method has also significant potential to estimate the liquid limit. Currently, available standards (e.g., ASTM D 4318 and BS 1377) offer reliable values of tanβ for determining the liquid limit using the one-point method. However, there is no suggested value of tanβ in the standards generally used in Bangladesh. There might be very limited studies that have investigated the value of tanβ for cohesive soils in Bangladesh. This study presents a reliable statistical analysis of liquid limit and plastic limit results of 495 soil samples to determine the appropriate value of tanβ. The analysis indicates a value of 0.132 of tanβ for cohesive soils in Bangladesh. 12 additional soil samples were subjected to liquid limit and plastic limit tests for validation purposes. Similar to other values of tanβ stated in different standards (e.g., 0.092 in BS 1377 and 0.121 in ASTM D 4318), the proposed value of 0.132 in the current study yields acceptable results of liquid limit values.

Keywords: Cohesive soil, liquid limit, one-point method, statistical analysis, tanβ.

SEISMIC SITE CLASSIFICATION BASED ON AVERAGE N_{30} VALUES IN FOUR SEISMIC ZONES IN BANGLADESH

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Abstract. Seismic zones and soil site classes must be considered during building design. Local soil site conditions with zone coefficient have a significant impact on a building vulnerability during an earthquake. To lessen susceptibility during seismic activity, the Bangladesh National Building Code (BNBC) - 2020 suggests using design response spectrum guidelines. The average shear wave velocity $\overline{V_s}$ is typically used for site classification if available. If not, the $\overline{N}_{30}$ value will be applied to the classifier for site classifications. Based on the measured SPT-N value up to a depth of 30 m of soil strata according to BNBC-2020, the average $\overline{N}_{30}$ value at 160 sub-divisional borehole locations throughout Bangladesh was determined in this work. Bangladesh is located in a deltaic basin mostly formed by alluvial deposition. The soils in most areas predominantly consist of alluvial silt, alluvial silt and clay, silty sand, or sand silt mixture, except in some hilly regions in the northern and eastern parts of Bangladesh. Apart from this, there is not so much information regarding seismic soil site classification across the country. This paper presents the seismic site classes (SA, SB, SC and SD) at different parts of Bangladesh. The soil site classes SD and SC are observed as the most dominant all over the country, except for a few locations in the hilly regions. The authors believe that this paper will provide an initial guideline to the structural engineers in designing an earthquake resilient building by selecting the appropriate soil site classes of any particular location in Bangladesh.

Keywords: $\overline{N}_{30}$ value, Soil site classes, Seismic zone, Response spectrum, Building vulnerability.

DETERMINING ENGINEERING PROPERTIES OF FINE-GRAINED SOILS USING ATTERBERG LIMITS

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Abstract. This study compares the Casagrande (ASTM) and fall cone (BS) methods of determining the Atterberg limits as well as investigates the relationships among these parameters and various engineering properties of fine-grained soils. 12 (twelve) soil samples consisting of three of each of the four inorganic soil types CH, CL, MH, and ML were tested. Disturbed soil samples were collected from various locations in Bangladesh, and laboratory tests including the hydrometer analysis, Atterberg limits, standard Proctor compaction, and drained direct shear tests were conducted. The relationship between the LL_{ASTM} and LL_{BS}, as well as the relationship between the PL_{ASTM} and PL_{BS}, were explored using regression analysis. For both cases, a linear trend was observed which matches the outcomes found in the earlier research. The shrinkage limits determined using the plasticity chart nearly matched with the experimental values supporting the earlier research. The optimum moisture content (OMC) was found to increase linearly with the increase of both LL_{ASTM} and PL_{ASTM}, as evidenced by previous research. In contrast, the maximum dry density (MDD) was observed to decrease linearly. The drained angle of internal friction (ϕ') was observed to decrease with the increase of the plasticity index (PI) similar to other research. The findings of this study will be useful for geotechnical experts in designing and analyzing structures and foundations on different soil types.

Keywords: Cohesive soils, Atterberg limits, Casagrande apparatus, fall cone method, compaction characteristics, shear strength, correlation.

GEOTECHNICAL SITE CHARACTERIZATION AND LIQUEFACTION POTENTIAL ASSESSMENT OF RECLAIMED SOIL IN JOLSHIRI ABASHON

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Abstract. Bangladesh is an earthquake-prone region. In the near future, it can witness an earthquake of magnitude 7 to 7.5 due to the origin of Dauki fault. Structures built on soft or loose soil can experience catastrophic damage due to liquefaction phenomenon during seismic excitation. Therefore, it is imperative to know the proper site characteristics and liquefaction susceptibility of earthquake-prone areas. Jolshiri Abashon is newly developed reclaimed land that is filled up with loose sand and has a higher chance of liquefaction. In this study, the subsoil condition and geotechnical parameters of soil have been evaluated for Jolshiri using the American Society for Testing and Materials (ASTM). The evaluated soil properties indicate that there are mainly three types of soil layers i.e., loose sand, low plastic silt, and dense silty sand. The upper layer consists of loose sand up to 7.5 m depth that is expected to have high liquefaction potential. The middle layer comprises very soft to stiff soil which can experience large settlements. The last layer is dense to very dense silty sand with high shear strength properties and low compressibility. Moreover, this paper aims to generate a liquefaction hazard map for the studied area in ArcGIS software based on Liquefaction potential index (LPI) value. The LPI value obtained for different boreholes shows a range around 20 to 30 which delineates that Jolshiri Abashon area has very high liquefaction potential.

Keywords: LPI, subsoil characterization, SPT, reclaimed land, ArcGIS, liquefaction, borehole.

EFFECTIVE MACHINE LEARNING MODELS FOR PREDICTING SPT-N OF RECLAIMED JOLSHIRI AREA, DHAKA

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Abstract. Accurate prediction of soil properties, particularly the Standard Penetration Test (SPT) N value, is crucial for urban multistory constructions. However, predicting SPT N values can be challenging in areas with diverse soil types and unique geological formations, such as the Jolshiri Abashon reclaimed land. To address this challenge, this study integrated existing field test data and utilized machine learning algorithms to create a prediction model for SPT N values and prepare a heatmap to visually represents the distribution and changes of the SPT N value with depth and other parameters. The study identified several parameters, including effective stress, depth, latitude, longitude, and soil type, that significantly influence the accurate prediction of SPT N values. Among the machine learning models employed, the Random Forest model exhibited the best performance, achieving a high R^2 value of 0.983, a low Mean Absolute Error (MAE) of 1.867, and a Root Mean Squared Error (RMSE) of 2.27. The Decision Tree model also performed well, with an R^2 value of 0.979, an MAE of 1.2528, and an RMSE of 2.53. However, the AdaBoost model demonstrated poorer performance in this context. Overall, this study highlights the importance of utilizing geospatial data and machine learning algorithms to accurately predict SPT N values in challenging areas like Jolshiri Abashon. The results demonstrate the potential for these techniques to improve the precision and effectiveness of estimation in soil engineering projects, ultimately leading to safer and more reliable constructions.

Keywords: SPT N value prediction, machine learning, Random Forest, Decision Tree, AdaBoost, Jolshiri Abashon.

FINITE ELEMENT ANALYSIS OF AN UNPAVED ROAD EMBANKMENT UNDER DRAWDOWN CONDITIONS

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Abstract. Unpaved roads play a crucial role in transportation infrastructure, particularly in rural and developing regions where limited resources prevent the construction of paved road networks. However, the stability of road embankments is a significant issue in Bangladesh. Two major contributing factors to this problem are changes in external water levels and external loading. This paper's objective is to examine how slope behavior changes in response to these shifts. Numerical modeling was conducted using the PLAXIS-2D software, based on the two-dimensional Finite Element Method (FEM). Slope stability analysis was performed considering different mechanical properties, such as the angle of internal friction (ranging from 20° to 35°) and cohesion (ranging from 2.5 to 10 kN/m2), along with different water levels (high water table, rapid drawdown, slow drawdown, and low water table). Additionally, investigations were conducted to assess the embankment's response to static loading. The results indicated that drawdown conditions significantly affected the embankment's stability, with permeability and drainage conditions playing crucial roles. Moreover, excessive external loading caused substantial instability, compromising the overall endurance of the embankment.

Keywords: Slope stability, Rapid drawdown, Finite element method. Numerical modeling, PLAXIS

EFFECTIVENESS OF MICROBIALLY INDUCED CALCITE PRECIPITATION (MICP) TREATMENT IN THE MITIGATION OF SEISMIC LIQUEFACTION: A REVIEW

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Abstract. Liquefaction is a significant contributor to earthquake damage, and traditional soil improvement methods such as soil densification, groundwater table lowering, sand grain bonding, and drainage have been used to mitigate liquefaction potential. However, these methods are energy-intensive and costly. In pursuit of economical and eco-friendly solutions for liquefaction mitigation, bio-mediated methods like bio-mineralization, biofilms, and biogas have emerged with promising progress. Microbially Induced Calcite Precipitation (MICP) is one of these bio-geotechnical approaches that has received a lot of research attention. MICP treatment increases soil strength and stiffness by precipitating calcite, which improves interparticle bonding. This paper presents a review of research articles on the use of MICP for liquefaction mitigation, focusing on factors such as cementation level, treatment cycle, initial density, and particle shape and size, as well as their impact on MICP performance. Experiment data focusing on excess pore water pressure, shear wave velocity, and axial strain are used to assess the efficacy of MICP-treated soil. However, the review identifies a scarcity of field studies that examine the effectiveness of MICP in light of practical geo-environmental variables. The study also discusses the potentials of MICP, such as long-term stability, scalability, and sustainability, as well as challenges, and makes recommendations for future research in this area.

Keywords: Liquefaction, soil improvement, bio-cementation, MICP.

EFFECT OF MOLD LENGTH ON LINEAR SHRINKAGE OF CLAYEY SOIL AND ITS RELATIONS WITH CONSISTENCY LIMITS

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Abstract. An experimental study was carried out primarily to investigate the effect of mold length on linear shrinkage of clayey soil. The swell shrinkage behavior of soil can be assessed in a quick in simplified manner by performing linear shrinkage test. Various agencies and authorities are using different sizes of mold especially its length in determining the linear shrinkage; the British Standard requires a 140 mm long mold, while the Indian Standard uses 125 mm, the Australian Standard on the other hand specifies two mold sizes: 130 mm and 250 mm. However, all of them uses the same diameter of 25 mm. Thus the hypothesis of relationship between linear shrinkage and mold length emerged. Three different linear shrinkage molds of lengths of 100 mm, 140 mm and 175 mm were fabricated. Eight clay soil samples were collected from selected locations of Bangladesh, and linear shrinkage tests were performed using these molds. Consistency limits, grain size distribution and specific gravity of the soils were also determined to identify and classify the soils. The relationship between linear shrinkage and consistency limits were also examined to context the soil condition of Bangladesh. Statistical analyses of the obtained data were done to explore the relationship proposition. A general trend of increase in linear shrinkage with the increased mold length was observed. The linear shrinkage was also found to increase linearly with increasing liquid limit and plasticity index. Good correlation with correlation coefficients (R^2) in the order of 0.712 was found between linear shrinkage and plasticity index. This agrees with the findings of other investigator. Linear shrinkage also exhibited a strong correlation with a regression coefficient (R^2) of 0.95 involving both liquid and plastic limits simultaneously.

Keywords: Linear shrinkage, mold length, liquid limit, plastic limit, plasticity index.

ENVIRONMENTAL MONITORING OF A NEWLY CONSTRUCTION RAILWAY PROJECT IN BANGLADESH

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Abstract. This study represents the environmental monitoring frameworks of the Khulna-Mongla Port Railway Project in Bangladesh. The railway alignment mostly passes through the paddy field, fish culture pond, and the medium populated area. 31Nos major-minor bridges and 105Nos box-culverts have been constructed along the alignment. The frameworks assess the surface water quality and airborne particulate matter's characteristics as air pollution near construction sites. This framework has been performed at six months intervals to assess water-air parameters according to Bangladeshi Standard and the Department of Environment. The particulate matter (PM_{10} and $PM_{2.5}$) and gaseous substance (NO_X and SO_2,) were assessed by battery operated automatic air sampler device. The grab water sample has been collected by pet bottle to send laboratory for evaluation of physio-chemical and bacteriological tests of surface water. For the evaluation of the environmental impact, the test results of all the parameters from water-air have been compared with prescribed standards. The findings of this study indicate that no significant environmental impact on nature was observed during the construction of bridge culverts and rail welding in this project.

Keywords: Surface water quality, environmental monitoring, air pollution, noise pollution, railway project.

WATER QUALITY ASSESSMENT OF THE DHAKA WASA WATER SUPPLY AND DISTRIBUTION NETWORK AT MIRPUR, DHAKA

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Abstract. The study aimed to assess the quality of drinking water in North Dhaka by collecting samples from 28 WASA connections in the Mirpur zonal zone. The majority of WASA connection samples received high-quality water, with no statistically significant differences between WASA water samples and household tap water samples. WASA's distribution network ensures safe drinking water by filtration processes, confirming hardness and fecal coliform levels in residential tap water. Despite Mirpur's adequate water quality, iron and total suspended particles were found in some locations, despite the dense population and lack of water health knowledge. The water is saved and used for drinking purposes.

Keywords: WQI, WASA, Tape water, physio-chemical properties, Water purifying process, Drinking water.

TREATMENT OF A TANNERY CHROME EFFLUENT BY ELECTROCOAGULATION

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Abstract. The tanning industry is recognized as a major sector producing severe industrial pollution worldwide. Tannery wastewater is challenging to treat due to its wide variety and many pollutants in high concentrations. For decades, chemical coagulation has been used to remove colloidal suspensions and soluble metal species from tannery wastewater. Electrocoagulation is an emerging technology that does the same thing at a lower cost. This research has been undertaken to determine the most effective electrode material for electrocoagulation. Firstly, tannery chrome effluent was collected from Savar Tannery Estate, and the wastewater was characterized for nine parameters. The parameters were EC, pH, color, Cr, TS, TDS, TSS, COD, and BOD. The electrodes used were made of stainless steel, mild steel, and aluminum. The number of electrodes was also varied to check the effect of the number of electrodes on the treatment process. The tannery chrome effluent was treated in six batches, each time using a different electrode configuration. Electrocoagulation was conducted for 90 minutes for each treatment process, followed by 30 minutes of settling time. Each of the treated wastewater was again analyzed for parameters. Stainless steel electrode has been found to be the most effective for chromium removal (99.6%). The aluminum electrode has been found to be the most effective for TSS, COD, and BOD removal (65.2%, 52.8%, and 18.8%, respectively). However, regarding overall pollutant removal, mild steel worked the best among the three electrodes (i.e., color, chromium, TSS, COD, and BOD removals were 97.9%, 99.2%, 59.8%, 49.8%, and 21.9%, respectively).

Keywords: Electrocoagulation, tannery wastewater, mild steel electrodes, aluminum electrodes, stainless steel electrodes, wastewater treatment, removal efficiency

URBAN STORMWATER INUNDATION MAPPING IN CHATTOGRAM CITY

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Abstract. Waterlogging has become the biggest obstruction for the people of Chattogram city especially during monsoon period. Waterlogging affects not only the economy, transportation, constructions but also the regular activities of day-to-day life of the city dwellers. The problems associated with waterlogging is so severe that measures should be taken to mitigate immediately. Therefore, this study aimed mapping of urban storm waterlogging which will aspire the present waterlogging situation of the city and hence to take the effective measures related to water logging issues. Waterlogging prone areas of Chattogram city were identified and flood inundation map was prepared for the city in this study. Flood inundation depths were collected from the selected 71 sampling points of the Chattogram City Corporation area. The waterlogging prone areas are categorized on the basis of the reasons for waterlogging in different drainage areas in Chattogram City. Chittagong Storm Water Drainage and Flood Control Master Plan was studied regarding these areas. 3D building model was later generated for creation of inundated area map using City Engine and ArcGIS 10.3. The study revealed that 15.44% (24 km^2) area and 25.4% buildings among 174915 nos. of Chattogram city gets inundated if flood occurs with 1m water depth. It is expected that the categories and the Map can be helpful for future research purpose and mitigation of waterlogging. With goodwill and honest effort, and proper economic support from the govt. we can hope to have a waterlogging free city.

Keywords: Water logging, City Engine, ArcGIS, Master plan, Inundation.

IMPACT ON SEDIMENT TRANSPORTATIONS IN A CHANNEL DUE TO IMMOVABLE BOULDERS ON CHANNEL BED AND PIER STRUCTURES OBSTRUCTING CHANNEL FLOW: A REVIEW

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Abstract. The movement of materials and the flow of rivers are consistently impacted by structures. One of the main causes of the channel's intensity of erosion and deposition is structural intervention. For the consideration of these processes, numerous experimental models are available. However, there are substantial differences between these models in terms of their complexity, inputs, and requirements, the mechanisms they reflect, how they are portrayed, and the kinds of information they output. This research examines various models of sediment transport in light of these elements. The approach taken in this review is to summarize the models, with a focus on experimentally based modeling. For boulder and structural interventions like pier, methods for figuring out the flow's ability to carry silt are presented. This study demonstrates the unique effects of boulder and intervention of pier on the sediment movement mechanism. However, this study didn't review models with explicit considerations of either sediment-associated nutrient transport or the effect of kinetic energy on sediment transport. While looking for models to explore erosion and sediment transport phenomena, it is predicted that academics, watershed managers, and decision-makers will find the review to be of interest. Due to the effects of structures in channels, this study recommends developing a multidisciplinary research agenda and future research opportunities relevant to river management and ecological enhancement.

Keywords: Sediment Transport, Experimental Modeling, Review, Watershed Management, Structural İntervention.

ASSESSMENT OF FECAL SLUDGE MANAGEMENT PRACTICES IN BANGLADESH: A CASE STUDY OF KUSHTIA MUNICIPALITY

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Abstract. Fecal Sludge Management (FSM) is a critical issue that affects the environment and public health in urban areas. This study aims to assess the fecal sludge management practices in a municipality in Bangladesh, Kushtia using the Shit Flow Diagram (SFD). The SFD is a tool used to visualize and quantify the flow of Fecal Sludge within a city from generation to final disposal. The study was conducted through field surveys, interviews, and secondary sources to identify the current fecal sludge management practices in Kushtia municipality. The SFDs were developed based on the data collected, and the findings were analyzed to identify the challenges and opportunities for sustainable fecal sludge management. The study recommends the implementation of source separation of waste, composting of organic waste, and establishment of sanitary landfills/ wastewater treatment plants for proper management of fecal sludge in Kushtia municipality. Additionally, the study recommends the development of public awareness campaigns to promote the adoption of sustainable waste management practices among residents. The SFDs developed in this study can serve as useful tools for policymakers and stakeholders to make informed decisions for the development of sustainable waste management practices in Kushtia municipality. This study emphasizes the need for proactive measures to ensure the sustainable management of Fecal sludge in urban areas, which is crucial for protecting public health and the environment.

Keywords: Shit flow diagram, Fecal sludge management, Sustainable waste management

SPATIAL ACCESSIBILITY ANALYSIS OF THE CYCLONE SHELTERS IN THE SOUTHERN PART OF BANGLADESH

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Abstract. Bangladesh is located in the tropical climate zone. Approximately 50% of the land is 7 m or less above and faces the Bay of Bengal. The coastal zone covers an area of about 33% of the country, representing 19 districts and 29% of the population. The area contains many special development opportunities which are constrained by very high concentration of natural and human induced hazards. Accordingly, the local geography produces not only the life-giving monsoon but also the catastrophic revenge of cyclone, tornadoes, thunderstorms and floods. Hence, cyclone shelter helps to reduce the losses. Cyclone shelters (CS) are the necessary infrastructures in the management of natural calamities, associated hazards and saving crucial lives, should be available in the vulnerable areas in sufficient numbers with sufficient facilities. But, the infrastructure & included facilities are not enough for the large number of vulnerable communities during emergency. The main goal of this study is to find out the areas deprived of Cyclone Shelter facilities by creating upazila-wise accessibility index depending on GIS based analysis, which attempted to link cyclone risk area to socio-economic, demographic aspects and housing conditions based on secondary data. A total of 109 upazilas of 16 coastal districts have been selected. The two-Step Floating Catchment Area (2SFCA) method is used to determine the accessibility index considering threshold distance. Among the 109 upazilas the accessibility index is quite lower in 61 upazilas, higher in 05 upazilas and zero accessibility in 43 upazilas. It is also found that the upazilas located near the coast have more accessibility than the remote upazilas. Therefore, some recommendations are suggested at the end of the study which might help the government and corresponding authorities to find out the locations need to build new cyclone shelters and ensure proper facilities at the existing shelters.

Keywords: Cyclone shelters, spatial data, accessibility index, secondary data, threshold distance, two-step floating catchment area (2SFCA) method.

PURIFICATION OF SURFACE WATER BY SAND FILTRATION WITH ACTIVATED CARBON

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Abstract. Surface water is polluted because of anthropogenic activity. Fresh and clean water is essential for all human beings living on the earth, yet it has been observed that worldwide millions of people are still using water contaminated by bacteria, toxic chemicals and other pollutants. So, there is a need for purification of water. The significance of this work was to improve the quality of surface water by using adsorption technique. In the recent study a low-cost water filter was designed for 17-liter capacity. The filter media consisted of 4 layers including pebbles, sand, corncob, and activated carbon, 4 cm of each component. The filtration capacity of the filter could be improved by adding 0.0001 μm filter paper. This research is based on the quality of surface water of Dhepa River, Sukh Shagor and sluice gate at Birganj in Dinajpur district. Samples of water from this source were collected and analyzed for the physical and chemical characteristics such as pH, Total Dissolved Solids (TDS), Turbidity, Hardness, Alkalinity, Biological Oxygen Demand (BOD), Potassium, Calcium, Magnesium, Sulphate and Sodium before and after filtration. Results showed that these filter media reduced the level of TDS, Turbidity, Hardness, BOD, Magnesium, Calcium, Sulphate and Sodium in appreciable amounts. Above all the parameters except magnesium brought below the limits of drinking water quality parameters given by World Health Organization. It was found that after filtering, surface water from these sources were usable for various domestic purposes and this filter was more cost effective than the other traditional filter available in the market.

Keywords: Surface Water, Filtration, Water Quality Parameters, Activated Carbon.

ANALYZING THE EFFECTS OF PM10 EXPOSURE ON HEALTH & ECONOMY, A CASE STUDY OF CHATTOGRAM CITY CORPORATION (CCC)

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Abstract. The primary objective of the present study is to evaluate the potential impact of PM_{10} on both the economy and public health within the Chattogram City Corporation Area (CCC), employing the BenMAP-CE software. The designated time frame for our study spans from 2019 to 2022, except for the year 2020, which was characterized by the global pandemic. The primary inputs utilized for evaluating the health impact consequences and economic benefits were Particulate Matter (PM_{10}) data, population data, incidence rates and relative risk values and Value of statistical life (VSL). The results revealed that over the course of the study period, there was a notable rise in the annual mean PM_{10} concentration value, surpassing the thresholds set by the World Health Organization. The year 2021 yielded significant health and economic advantages because of the dense population and elevated levels of particulate matter observed during this timeframe. According to projections for the year 2021, a reduction in PM_{10} levels is anticipated to have a significant impact on public health outcomes. Specifically, it is estimated that such a reduction could potentially avert approximately 19,122 deaths across all age groups, encompassing various causes of mortality such as cardiovascular diseases and respiratory ailments. Additionally, this preventive scenario could yield a financial benefit of approximately 563 million USD, stemming from the avoidance of these premature deaths. Furthermore, cardiovascular disease accounts for 18% (3,514 out of 19,122) of these avoidable deaths, while respiratory disease contributes to 21% (3,964 out of 19,122) of the total avoidable deaths. Future research endeavors should consider the elimination of limitations, such as insufficient regional data and the consideration of relative risk. This study suggests implementing specific strategies for the purpose of effectively managing and reducing the levels of ambient particulate matter, with the aim of protecting public health in future time periods.

Keywords: mortality, health impact, economic benefit, PM_{10}

A STUDY ON CLIMATE VARIABILITY AND GROUNDWATER DROUGHT IN NAOGAON DISTRICT USING REMOTE SENSING

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Abstract. Climate change is the progenitor of all complexities which are more significant, intricate and unpredictable than any other environmental issues. Lowering annual rainfall and diminishing surface water bodies are two indicators of climate change which have significant impact on groundwater depletion. The northwestern part of Bangladesh is suffering from water scarcity and heading towards a foreseeable groundwater drought situation. The objective of the study is to find how climate change accelerates groundwater depletion. The study analyze rainfall data and trend of diminishing surface water bodies in Porsha and Sapahar upazila of Naogaon district. Surface water bodies have been analyzed using IsoCluster Unsupervised Image Classification in ArcMap 10.6. Rainfall data have been collected from Bangladesh Meteorological Department (BMD) and Bangladesh Water Development Board (BWDB). Then magnitude, frequency and pattern of annual rainfall have been analyzed. Further, Geographically Weighted Regression (GWR) analysis was done in ArcMap 10.6 for the decreasing trend of annual rainfall and surface water bodies to predict future Groundwater Table (GWT) depletion data. When the predicted GWT data converges with the observed GWT data; it is apparent that climate change accelerates rapid GWT depletion. The study result showed the convergence of predicted data and observed data on GWT where climate change plays an unseen pivotal role.

Keywords: Climate Change, Geographically Weighted Regression, Groundwater Table, Rainfall, Surface Water Body

INTEGRATING EMBODIED CARBON AND COST REDUCTION STRATEGIES IN BUILDING DESIGN: A FRAMEWORK CONTRIBUTION

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Abstract. Sustainable building practices demand the integration of both environmental and economic factors in the design process. Among the environmental considerations, embodied carbon emissions from building materials and construction activities have a significant impact on a building's overall carbon footprint. Moreover, construction costs play a crucial role in the feasibility and profitability of a building project. Thus, it is essential to develop a framework that integrates strategies aimed at reducing both embodied carbon and construction costs during the design phase of buildings. The framework is demonstrated through a case study of a commercial office building. This paper presents a comprehensive framework for integrating embodied carbon and cost reduction strategies in building design. The study encompassed the entirety of the life cycle, which includes the stages of material production, construction, occupation, maintenance, demolition, and disposal. The inventory data was simulated within an LCA model, and subsequently, the environmental impacts were calculated for each stage. The evaluation focused on three environmental impact categories that are considered: global warming potential, acidification potential, and photo-oxidant formation potential.In the baseline assessment phase, a life cycle assessment and cost estimation tools are employed to estimate the embodied carbon and construction costs of the building. The findings indicate that steel and concrete are the predominant materials in terms of both quantity utilised and their corresponding environmental effects during the manufacturing process. These contributed 25% and 42% of global warming potential. The overall photo-oxidant production potential was 40% and 28%, respectively, while the total acidification potential was 35% and 42%. The operation stage dominated the life cycle environmental impacts of commercial buildings, accounting for 50% of global warming potential. The proposed framework provides a useful tool for building designers, developers, and policy makers to achieve sustainable building practices that balance environmental impact and economic feasibility.

Keywords: Embodied carbon, cost reduction, sustainable building practices, life cycle assessment, construction process improvement.

ANALYZING THE ROLE OF GORANCHATBARI PUMP STATION AND ITS PERFORMANCE IN REDUCING WATER LOGGING PROBLEM OF DHAKA CITY

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Abstract. Dhaka is one of the largest and the most densely populated cities in the world. Being located in the tropical region with intense rainfall of around 2300 mm/yr, it undergoes persistent waterlogging almost every year. The city and its dwellers suffer a lot due to such waterlogging, especially during the monsoon season from May to October. Being cordoned by a flood protection embankment, few pump stations of the city mostly do the job of removing logged water to the nearby rivers. The main objective of the study is to investigate the causes of waterlogging and the performance of a pump station to reduce it, which is located at Goranchatbari in the north western part of the city. Satellite image analysis and GIS based mapping of drainage network, field visits, questionnaire survey, rainfall and pump station data analysis and reports in the newspaper were analyzed to get a preview of the causes of waterlogging. It concluded that unplanned drainage, blockage of existing drains and encroachment, inadequate pumping facilities are the main reasons for flooding in the region, so that water cannot reach up to the pump station. For precise analysis, the catchment area was divided into five zones of almost similar land uses. Based on the future projections of sub catchment land uses as well as future climate change scenarios, projected change in runoff was estimated. It has been found that under both the scenarios, the drainage congestion will aggravate further. Suggestions were then made to identify the hot-spots, fix areas of drainage blockages, re-exchange of extinct canals and increase the capacity of Retention Pond in front of the pump station.

Keywords: Water logging, Embankment, Dhaka, Pump Station.

AN ANALYTICAL STUDY OF LAND USE AND TRANSPORTATION SCENARIO IN DHAKA FOR TRANSIT-ORIENTED DEVELOPMENT: STEERING TOWARDS SUSTAINABILITY

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Abstract. Transit-oriented development (TOD) is a revolutionary planning approach that fosters economic, environmental, and social sustainability by seamlessly integrating land-use and transportation planning. Therefore, this study aims to investigate the impact of Dhaka's land use and transportation on the implementation of TOD. Dhaka, the capital of Bangladesh, faces serious challenges that affect residents' quality of life and hinder sustainable development. The growing population and uncontrolled urbanization make it necessary to re-evaluate the current situation. Therefore, data from a questionnaire survey and reliable secondary sources were collected to obtain a clear picture. After a detailed analysis of the collected data, this study comprehensively assessed Dhaka's land use and transportation scenario, including public transportation, land use patterns, and mobility trends. It also evaluates the feasibility of TOD implementation and the role of sustainable transportation and land use planning in supporting TOD. Moreover, this study identifies the challenges and barriers to TOD implementation. Nevertheless, this research provides a valuable contribution to understanding Dhaka's land use and transportation, supporting the potential of TOD. Finally, it offers practical recommendations for policymakers, transportation planners, and stakeholders interested in improving the urban footprint and promoting sustainable development through integrated land use and transportation planning. This study also discusses some limitations in the future scope of the study.

Keywords: Land use, urbanization, mobility, public transportation, transit-oriented development, sustainability, TOD policy.

INVESTIGATING DHAKA-KHULNA (N8) EXPRESSWAY COMMUTERS' PERCEPTIONS ON TRAVEL MODE CHOICE ACTIVITY PATTERNS: USING MULTINOMIAL LOGISTIC REGRESSION MODEL

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Abstract. This paper investigates the Dhaka–Khulna (N8) expressway commuters' perception on travel mode choice activity patterns. Hence, a well-structured questionnaire is prepared that includes the participants' sociodemographic profile, travel history, safety issues, and perceptions. Randomly, 300 commuters are chosen for a face-to-face interview. The qualitative data sets are analyzed using a multinomial logistic regression (MLR) model. Analysis shows that 58% of commuters are traveling for private job purposes; their age and monthly income range are 25–40 years and Tk. 10,000–20,000, respectively. Commuters travels by bus (49.3%), auto-rickshaw (17%), motorcycle (11%), rickshaw (10.7%), car (7%), bicycle (4%) and walking (1%). Among them about 29% bus users travel cost is between Tk. 100–300 on a daily basis. However, they are enjoying travel long distance within a short time, highway safety measures, scenic daytime and nighttime roadside beauty, and amicable tree plantations. But participants significantly stated that roadside electric poles and large billboards harm this highway's aesthetic and natural beauty. Also, it has become accident-prone for young bikers and car drivers' reckless driving. This research will help the highway authorities to improve public transportation facilities by prioritizing commuters' travel activity patterns.

Keywords: Commuters' perception, travel mode choice, multinomial logistic regression model, trip activity pattern, expressway.

BRIDGING THE GAP: A SYSTEMATIC ANALYSIS AND DESIGN OF U-LOOP POST-TENSIONING BOX GIRDER BRIDGES WITH THE AID OF CSIBRIDGE SOFTWARE.

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Abstract. This paper presents a study of the design and analysis of U-loop prestressed box girder bridges using the CSiBridge (2016) software and Excel spreadsheet. The study was conducted to address the increasing traffic congestion problem in Dhaka, the capital and largest city of Bangladesh. The proposed solution was a U-loop bridge, which utilized the advantages of AASHTO-PCI-ASBI box girder sections. The analysis considered dead and live loads, as well as prestressed loads, which were verified using the CSiBridge software. This provides valuable information for bridge engineers and offers a potential solution to the traffic congestion issue in Dhaka. The study utilized the CSiBridge software to model the bridge, considering the linear elasticity of all elements. To simulate real-world scenarios, the software-defined lanes for live loads to act on the superstructure using the standard truck HL-93 as per AASHTO LRFD (9^{th} edition) design codes. The study aimed to provide a design guideline for the required tendon and reinforcement for U-looped Concrete Box Girder Bridges. Overall, this study provides a valuable resource for bridge engineers looking to design U-loop prestressed box girder bridges and contribute to the reduction of traffic congestion in urban areas, particularly in Dhaka.

Keywords: U-loop bridge, box-girder, prestressed concrete, AASHTO-PCI-ASBI, CSiBridge, analysis, design.

ASSESSING ROAD PROFILES USING GPS, ROAD MAPPING USING ARC-GIS AND ANALYZING THE EFFECT OF SPEED BREAKERS ON VEHICULAR SPEED REDUCTION

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Abstract. This study primarily focuses on how using GPS and Arc-GIS can combinedly help to detect the reasons behind traffic congestion problems in Dhaka city and mitigate this problem to some extent. For this paper, a particular main road and 3 sub-roads have been selected. The selected main road is Mirpur-10 to Bangladesh University of Engineering and Technology (BUET) (via Farmgate) both ways. The 3 sub roads are Mirpur-2 (60 Feet Road), BUET (Palashi Road) and Amtoli to Gulshan-1 Road. Also, a profile of that particular main road has been prepared using GPS and from that profile, a number of road maps have been prepared using Arc-GIS. For analyzing the reasons behind traffic congestion, the existence of some important roadway parameters has been selected which are- foot over bridges, underpass, speed breakers, traffic signs, traffic signals, roadside dustbins etc. Also, the impact of speed breakers upon the speed of motorized vehicles (private cars) has been analyzed for the 3 sub roads for a 100 m segment. A comparison has been shown between the speed of those vehicles with and without speed breakers. The deficit of speed of those vehicles has also been analyzed and some suggestions have been proposed on how this problem can be solved. This study will be very effective in providing information about those points where the traffic congestion will occur, how the time lost due to congestion can be minimized, and also will provide roadway safety to pedestrians.

Keywords: Traffic congestion, roadway parameters, longitude, latitude, speed reduction, pedestrian safety.

ARTIFICIAL INTELLIGENCE-BASED PERCEIVED MOTORCYCLE RISK PREDICTION IN BANGLADESH'S URBAN DRIVING ENVIRONMENT

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Abstract: Bangladesh has the highest fatality rates for motorcycle accidents worldwide, accounting for the largest portion of the total road crashes, and the rate has been increasing for the last couple of years. In 2022, data from the BUET Accident Research Institute (ARI) revealed that, because of accessibility, affordability, and ride-sharing usage, motorcycles account for 62% of the total number of vehicles plying the roads, with 26 accidents for every 10,000 motorcycles. So, it is imperative to investigate motorbike accident precursors, their contribution to endangerment, risk prediction, and devise necessary policy implications.

In this study, perceived risk data were collected through offline and online questionnaire surveys from 1,559 respondents. Demographic data like age, gender, residence division; usage criteria of motorbikes, occupation, ridesharing app usage, and rating on the perceived risk of 38 precursors of motorbike accident in Bangladesh's context were collected. Later precursors were clustered into 10 major combined attributes: biker's driving behavior, motorbike condition, safety status, weather environment, pavement condition, driving environment, sign marking and lighting, traffic control, traffic movement, and pedestrian activity. Random Forest algorithm has been used to predict perceived risk due to driving environment with 70% accuracy. Lastly, different contour maps for features' correlation, feature importance, heat map, deployment of results in public server for user interface, and policy implications have been demonstrated in this study. In summary, the proposed prediction tools will have a significant prospect for accident analysis and prevention in the urban context of any developing nation.

Keywords: Perceived risk, questionnaire survey, machine learning, feature importance, contour map.

COMPARATIVE STUDY ON AIR POLLUTION DUE TO GAS EMISSION AND ENERGY CONSUMPTIONS OF ELECTRIC AND INTERNAL COMBUSTION ENGINE VEHICLES

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Abstract: The air quality of Bangladesh has been degrading rapidly in the last decade. Dhaka, the capital of Bangladesh, has been recognized as one of the world's most polluted cities in terms of air quality. One of the major sources of air pollution is vehicular emissions, concentrated mainly in the cities. The rising rate of air pollution has effects that are hazardous for the environment in the long run. In order to reduce air pollution due to vehicular emissions, the uses of electric vehicles have been suggested in numerous scientific research works. This study reviews the extent of air pollutant emissions by electric vehicles during their life and compares the result with the values of emissions by traditional internal combustion engine vehicles used in Bangladesh. This study is based on the data and findings of previously published scientific literature. From the analysis, it can be concluded that electric vehicles produce a lower quantity of emissions of CO_2, VCOs, NO_X, and SO_2 in total than that internal combustion engine vehicles. However, the increased use of electric vehicles will cause extra pressure on the country's power generation sector. It is also suggested that the sources associated with the power consumption of electric vehicles should be replaced with less contaminating sources to reduce the overall emission caused by electric vehicles. This study will provide an overall preview of the challenges involved in introducing electric vehicles in Bangladesh from the perspective of its impacts on air pollution and energy consumption.

Keywords: Air quality, vehicular emissions, Electric vehicles, CO_2, VCOs, NO_X, SO_2, air pollution, energy consumption

CRACKING BEHAVIOR OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENT (CRCP) ON NATIONAL HIGHWAY IN BANGLADESH

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Abstract. The traffic volume is rapidly increasing on National Highways of Bangladesh. To ensure mobility in the future, least consequential cost in road development and maintenance with maximum service life is necessary. Continuously reinforced concrete pavement (CRCP) has the potential to provide a long-term service life with "zero-maintenance" under heavy traffic loadings and challenging environment. To cash-out this benefits, very first CRCP with Slip-form paver has constructed on National Highway-5. The pavement consists of 275 mm CRCP slab, 100 mm Lean Concrete Base (LCB), 150 mm thick subbase with 0.85% in total reinforcement content placed in two layers into CRCP slab. This study aims to investigate cracking behavior of CRCP through experiences of different countries. In CRCP, transverse cracking is allowed but this crack pattern is controlled by the continuously placed longitudinal reinforcement. This crack pattern could not always follow as desired and long-term performance would be affected. The study revealed that combined aggregate gradation and construction practices can be linked to formation of variable transverse crack patterns, its spacing and longitudinal cracking. Absence of combined gradation envelop and performance checking charts is the major flaw of the CRCP Specification. Active crack control through saw cutting seems effective to reduce unwanted crack patterns and crack width. Structural capacity of the pavement has been evaluated through FWD deflection. The load-centered sensors' deflection (D_0) values varied from 43 to 73 μm which is reasonable irrespective to crack pattern. The findings of this research can be useful for further modification of CRCP practices in Roads and Highways Department (RHD).

Keywords: Transverse crack, longitudinal cracks, crack spacing and width, crack pattern and active crack control.

PERCEPTION OF COMMUTERS ABOUT LOCAL CITY BUS SERVICES IN DHAKA– A CASE STUDY IN GABTOLI TO NEW MARKET ROUTE

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Abstract. Buses have long been the most affordable and convenient kind of public transportation. In Dhaka, people often complain about poor inaccessibility of bus services specially in perspective of female commuters. People are frequently observed standing in the buses during peak hours as they travel to their destinations. The infrastructure for local bus services needs to be improved in order to maximize the efficiency of public transportation networks. This paper is about a case study in one of the most congested routes of Dhaka city, "Gabtoli to New market". A survey has been conducted in this route in the peak hours to find about the deficiencies of different bus services. A questionnaire survey has been provided to people using the routes about different attributes from seat comfortability to safety issues on a scale of very poor to excellent. 300 people were surveyed in the process for reliable data. 35% commuters ranked the bus services very poor according to their satisfaction levels. 34% responses revealed that seat comfortability is in very poor condition in addition with 42% people felt very unsafe inside riding the buses. Apart from the surveys, the usage of public buses has also been measured in important points in the designated routes. Increasing awareness about the utilization of public buses is crucial to reducing traffic congestion because they can carry more people. This paper will present the idea that local bus systems should be enhanced to make them more effective as a form of public transportation.

Keywords: Bus, passengers, service quality, public transport, survey.

USER PERCEPTION OF CITY BUS SERVICE QUALITY IN 'NEW-NORMAL SITUATION': A CASE STUDY OF DHAKA, BANGLADESH

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Abstract. The development of sustainable transportation within Dhaka city has been a key issue over the years. Moreover, the pandemic has created a new-normal chronicle in human lives escalating a fear of being unsafe in public transport during the pandemic. So, it is paramount to bring back public transport as an attractive mode in the post-pandemic period. In this context, service quality (SQ) of bus attributes is an effective parameter to analyze because an improvement in the quality of the service of city buses leads to higher satisfaction of the passengers, which in turn leads to increased use of public transport system. Hence, the authors aim to analyze the user perception of the service attributes of city buses and their service quality in Dhaka City by applying Bayesian Ordered Logistic Regression (BOLR). The BOLR model results reveal that Security inside the Bus has the highest importance with a posterior mean value of 1.036 and Crowdedness has the least importance with a posterior mean value of 0.283 on the overall SQ of city buses. Moreover, out of the 16 attributes analyzed, Service Frequency, Crowdedness, Staff Behavior, Lighting Facility, Structural Condition of Bus, Female passengers' Safety from Harassment, Punctuality and Reliability, and Security inside Bus are found to be the significant attributes that can impact the overall SQ of city buses. Lighting facility affected their perception of the bus cleanliness as well-lit buses helped more to reveal whether the bus amenities were clean or not. Females also feel safer in well-lit areas. These findings would help policymakers and transport planners to focus and work on these significant attributes to sustain the existing users and attract new users in this new era and provide access to safe, affordable, accessible, and sustainable transport systems for all.

A DECISION SUPPORT CONCEPTUAL FRAMEWORK FOR SELECTING THE OPTIMALLY EFFECTIVE TEMPORARY TRAFFIC MANAGEMENT STRATEGIES FOR THE UNDERGROUND METRO RAIL STATION CONSTRUCTION WORKS IN A DENSELY POPULATED METROPOLIS

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Abstract. Temporary Traffic Management for a construction project on a Metropolitan main corridor involves a higher level of challenges when it employs long-term lane closure at multiple locations. A mega project for constructing the first ever underground metro rail facilities (MRT, Line 1) is undertaken along a heavily congested route of Dhaka Metropolis. Twelve underground metro rail stations are planned to be constructed along the route, which may require longer-term one-directional lane closures. To minimize the adverse impacts on road users due to the prolonged occupation of road areas as work zones, the executing agency must employ optimally effective Temporary Traffic Management (TTM) strategies at the stage of work planning. However, without a proper decision-making procedure for the selection of effective TTM strategies, the adverse impact on road users could not be minimized. This paper is part of an ongoing research work, which will empirically test the proposed decision support framework for selecting the optimally effective TTM plans, dedicated to the underground metro rail station construction works for a congested corridor in Dhaka Metropolis. This paper aims to outline a decision support conceptual framework for the project executing agency and the concerned practitioners to help select optimally effective TTM strategies. The outcome of this paper will help the concerned project authorities to better evaluate, determine, and take decisions on selecting TTM strategies for longer-term underground construction work on a busy urban corridor.

Keywords: Temporary traffic management strategy, underground metro-rail station construction, decision-support framework.

A STUDY ON PARKING CHARACTERISTICS AT SOME IMPORTANT LOCATIONS IN DHAKA CITY

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Abstract. This paper is aimed to present the overall parking scenario at some major locations of Dhaka City. Study is done to explore the on street and off street parking scenario in some major places of Dhaka. Study area was selected based on land use pattern and importance of the area. The study area was New Market, Motijheel and Baily road where on-street parking is causing serious problems on smooth road traffic operation. Survey was conducted both weekday and weekend to identify the overall parking characteristic using data of parking accumulation, parking supply and demand, accumulation, parking load, spill over, and parking fees. From survey, it's been clearly observed that existing parking supply is not enough to fulfil the demand, so it leads the vehicle operators to illegal parking. In Motijheel, on weekdays there are lots of illegal parking, no regulation, unwillingness of using off street parking facility, lacking of individual parking facilities, etc. In New Market area there is not enough off street parking facilities and huge parking space crunch in both weekday and weekend, the scenario is worst in weekend. Baily road is a mix area which offers a good off street parking facility but in peak hour it's on street parking supply struggles to meet the demand. Based on supply, demand and accumulation, it can be recommended that, as the land use pattern of the study areas are different, parking sharing capacity can be effective to meet the inconsistency in supply and demand.

Keywords: Accumulation, parking supply, demand, off-street parking, on-street parking

GIS-BASED MAPPING OF SEISMIC RESPONSE ASSESSMENT DUE TO EARTHQUAKE VULNERABILITY OF WARD 33, DHAKA

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Abstract. The capital of Bangladesh, Dhaka is one of the most densely populated cities in the world; puts it at high risk in an event of a massive earthquake or any emergency outbreak. This study shows how to incorporate GIS (Geographic Information System) as a tool to expose seismic vulnerabilities of selected urban areas, therefore identifying the lack of emergency response time capacity of such cities. For study purposes, a sample of 400 buildings has randomly been selected to analyze earthquake vulnerability using RVS (Rapid visual screening); a method established by FEMA (Federal Emergency Management Agency). The methodology includes three different approaches for combining a final vulnerability score. From field surveys and satellite data, an optimum route model has been established to represent the emergency response time of firefighting agencies in congested as well as free flow conditions. To analyze rescue and accessibility, buffer areas are created with different road widths using ArcGIS 10.08 software. The composite vulnerability score incorporating RVS, rescue accessibility, and emergency response time is finally analyzed and represented in ArcGIS; producing maps for concerned authorities to use in an emergency earthquake hazard. In conclusion, some recommendations and further research scope have been discussed to improve the assessment.

Keywords: GIS, structure, transportation, earthquake, spatial analysis, hazard, disaster management, emergency response capacity.

INTEGRATION OF INTELLIGENT TRANSPORTATION SYSTEM (ITS) WITH CONVENTIONAL TRAFFIC MANAGEMENT IN DEVELOPING COUNTRIES

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Abstract. Traffic management is a global challenge, with traditional techniques proving inadequate to manage modern movement complexity and dynamism. Intelligent Transportation Systems (ITS) are being integrated into traffic management systems across different countries to address these major challenges. ITS technologies are addressing traffic challenges, such as route choice, real-time traffic information, augmented signage, fleet management, emergency vehicle management, and many more. While developed countries are experiencing positive outcomes from ITS implementation, it is much more challenging in developing countries, where variations in infrastructure, funding, technical expertise, and lifestyle must be considered. Despite these challenges, simple communication technologies such as GPS, Wi-Fi, microphones, cameras, accelerometers etc. can be used for feasible ITS implementation. The goal of this study is to find out feasible ways to include ITS in the traffic management systems of developing countries through the use of readily available technologies which can be used in procedures like detecting and locating potholes, providing additional safety and environmental news to road users, and monitoring traffic flow, etc. Adaptation of ITS in developing countries requires modifications compared to the Western ITS standards. This study thoroughly analyzes the many implementation techniques in developed countries and research works conducted in these domains and suggests potential adaptation techniques or strategies and required modifications which can be used to transform the conventional traffic management system of developing countries into a much more effective and efficient one.

Keywords: Transportation, intelligent transportation system, developing countries, technologies, traffic management.

PLANNING FOR A SUSTAINABLE STREETSCAPE A STUDY OF TRANSPORTATION SYSTEM AND PEDESTRIAN ISSUES OF NEW MARKET AREA, DHAKA, BANGLADESH

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Abstract. The existence of a sustainable streetscape is one of the most important components of a sustainable city. The design and upkeep of streets and sidewalks can positively or negatively affect the choices and actions of locals. The sustainability, economy, livability, and health of the city will all be enhanced by a cozy network, which will promote walking, socializing, and using public transportation. A well-designed pedestrian network with a reliable transportation system will enable travel that is of high quality, safe, and equitable for the entire population, as well as having a good impact on the environment. The New Market neighborhood of Bangladesh's capital city Dhaka is one of the busiest areas in the country. Because of its regional uniqueness, the site has developed into a popular gathering place for many people. Unfortunately, due to the extreme population density and the level of traffic congestion, it has steadily become more difficult for people to stroll around. Additionally, the area's public transportation options and traffic circulation infrastructure are insufficient for moving crowds of people. Moreover, most pedestrians decide to cross the road in a dangerous manner without using overpasses, which ultimately results in a variety of traffic mishaps. Also lacking in this area are the appropriate pedestrian facilities that a healthy streetscape ought to have. Illegal markets, footpaths that are occupied, broken footpaths, abrupt changes in footpath width, and other factors make it more difficult for pedestrians to go about. This study's main objectives are to evaluate the existing state of the neighborhood's roads, transportation systems, and pedestrian facilities, pinpoint problems, and offer alternatives for sustainable policies and a better streetscape that adhere to standards.

Keywords: Pedestrian, traffic congestions, public transportation, sustainable city, environment, streetscape.

MODE CHOICE MODELING OF UNIVERSITY FACULTIES IN DHAKA: A CASE STUDY OF BUET

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Abstract. The transportation needs of individuals affiliated with educational institutions, such as universities located in metropolitan areas, are diverse and essential for the proper planning of a city's transport infrastructure, especially for the capital city of a developing country like Bangladesh. Unlike other organizations that follow a fixed schedule, university people, especially faculties, have flexibility in their choice of mode and time of travel depending on their schedules and preferences regarding the transport mode. Additionally, a variety of factors, such as gender, income, travel time, distance, and cost, have an impact on their mode of transportation. This research concentrates on the mode choice behavior of faculties using a discrete choice modeling approach to identify the key variables influencing their choice. Using revealed preference (RP) surveys, travel information was gathered from the faculties of Bangladesh University of Engineering and Technology (BUET). This study emphasized the mode choice of non-resident faculties at BUET. Multinomial-logit models were developed using the open-source statistical software BIOGEME. The findings of this study will signify the major contributors in the mode choice behavior of university faculties and contribute towards the betterment of the city's overall transportation system, leading towards a sustainable and equitable society as well as acting as a guide for other metropolitan areas having similar settings.

Keywords: Transport mode, discrete choice models, stated preference survey, multinomial-logit models.

AN EMPIRICAL INVESTIGATION ON USER SATISFACTION OF RIDE SHARING SERVICES: A STRUCTURAL EQUATION MODELLING APPROACH

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Abstract: Ride-sharing service is undoubtedly a well-accepted technology resolution to the people living in cities worldwide. Investigating users' perception on satisfaction of ride-sharing services in Bangladesh is the main objective of this study. Structural equation modeling (SEM) was used to develop an empirical model to identify the relationships between major attributes that affect ride sharing services' user satisfaction. The model was calibrated using collected data of 653 ride sharing service users who were interviewed with a formal questionnaire. Demographic data like age, gender, occupation, income range along with rating on of 15 observed variables of ride sharing services on user satisfaction in Dhaka's context was collected. Later observed variables were clustered into two latent variables i.e., service quality and usability which focuses on ultimate user satisfaction. Finding reveals that ridesharing users give most priority on the efficiency in arriving at destination by rider (driver) and on riding comfort for service quality and usability respectively. Covariance between these two variables tend to move in the same direction. Again, it is found that user satisfaction is highly influenced by service quality compared to usability. Hence this research work concludes with some recommendations to ensure betterment of overall user satisfaction. This study will help officials to develop a regulatory framework for Ride Sharing Services in order to attract more users.

Keywords: Ride sharing services, user satisfaction, observed variables, latent variables, structural equation modelling.

SHORT-TERM AGING BEHAVIOR OF BITUMEN COMMONLY USED IN BANGLADESH FOR ROAD CONSTRUCTION

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Abstract. The engineering performance of bituminous pavement highly depends on the aging processes of bitumen. A developing nation like Bangladesh mostly depends on imported bitumen along with locally refined limited sources. Engineers often face significant challenges and concerns when early cracks develop in the field performance of bitumen. It is essential to evaluate the aging behavior of bitumen to ensure better performance in the field. This study aims to determine the degree of aging by investigating the short-term aging behavior of commonly used bitumen in Bangladesh. A total of five randomly selected samples were collected for the characterization of bitumen, one of which was local and the rest were from foreign sources. A series of tests were conducted to determine elastic recovery, penetration, softening point, and ductility of the bitumen before and after aging. Short-term aging was carried out in the laboratory utilizing the Rolling Thin Film Oven. A wide range of variation in the degree of aging was observed for the similarly graded different bitumen samples. Based on the penetration test, sample BS-1 showed the highest degree of aging, with a value of 66.47%, while sample BS-2 had the lowest degree of aging, with a value of 46.82% among the collected bitumen samples. The significant variation observed in the degree of aging among the samples suggests that the field performance of bitumen is also likely to vary accordingly. The observed variation in performance matches the occurrence of pavement failures in our country. The findings of the study will direct engineers to be careful while selecting bitumen for road construction.

Keywords: Bituminous Pavement, Degree of Aging, Commonly Used Bitumen, Field Performance.

A CASE STUDY ON THE EVALUATION OF STREET LIGHTNING PERFORMANCE EFFICIENCY IN THE DHAKA METROPOLITAN AREA

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Abstract. Dhaka is the busiest city in Bangladesh, with heavy traffic flow at night. In an urban setting, insufficient natural light on the street at night is always a problem. The safety of road users and pedestrians is the biggest challenge, as several road accidents, hijackings, and other crimes occur at night due to poor street lighting performance. This study explores the current state and assesses the illumination performance of existing street lighting systems at different locations around the Dhaka metropolitan area. A questionnaire survey on road user's opinions on the existing street lighting system are also conducted to figure out the public perceptions for night time mobility. The study has found that the existing condition of street lighting systems in Dhaka, especially on the city arterials and local streets, are inadequate and out of urban standards. The arrangement of lights is found irregular and most of the location experiences inefficient street lighting systems as per AASHTO guidelines. This study offers a set of proposals for different types of roads (arterials or local streets) that provide safe pedestrian mobility and vehicular flow at night.

Keywords: Dhaka Metropolitan, Urban Area, Street Lighting System, Illumination Performance, Road Safety, Public Perceptions.

VISUAL ASSESSMENT OF SELECTED ROADS OF DHAKA CITY

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Abstract. This study deals with the identification and investigation of the deterioration of the pavement surfaces of selected roads in Dhaka city. Deterioration reduces the pavement life to such an extent that reconstruction is needed before their expected life span. Because of the inadequacy of highly sophisticated equipment and software, we went through a less accurate but very effective "Visual Assessment Method" of the Roads and Highways Department (RHD) and Direct Rating Method (DRM). From the evaluation of 19 streets, it has been found that most of the streets in Dhaka city have deteriorated due to heavy traffic movement, bad drainage, and utility works mostly in the rainy season. From the analysis, done on the selected streets, according to the RHD method only 11% of road pavement is in good condition and 16% of road pavement is in poor to fair condition. On the other hand, according to the DRM method, 21% of road Pavement is in poor condition and 31% of road pavement is in good condition. This adverse effect on the roads can only be improved by proper maintenance, effective coordination among the utility agencies, and proper control and supervision in their work.

Keywords: pavement deterioration, visual assessment, reconstruction, maintenance, traffic movement.

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IMPACT OF A DEDICATED BICYCLE LANE AT A SELECTED INTERSECTION

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Abstract. This study aims to evaluate the impact of a separated bicycle lane in Gulshan, an upscale district in Dhaka city, to alleviate traffic congestion during peak hours. The demand for vehicular transportation in Gulshan is high due to its multiple foreign embassies, corporate offices and high-end commerce, resulting in a traffic capacity that often surpasses peak-hour traffic. With a modal share of 9%, bicycles were considered as a viable transportation mode. Using VISSIM model, the existing roadway configuration was compared with a roadway section that includes a separated bicycle lane, considering the level of service (LOS), travel time, queue length and greenhouse gas emissions. The introduction of a separated bicycle lane resulted in a reduced volume-to-capacity ratio (V/C), thus improving the LOS of the roadway section. The overall LOS of the roadway section was upgraded from E to C and queue length and greenhouse gas emissions were also reduced. The stop delay was reduced by 71% due to the removal of all non-motorized vehicles from the motorized vehicle lane, making the traffic more homogenous. Thus, the study suggests that the implementation of a dedicated bicycle lane in a busy area like Gulshan can help improve the overall traffic condition.

Keywords: Bicycle Lane, traffic congestion, Volume to Capacity ratio (V/C) VISSIM model, level of service, modal share, queue length, stop delay, bicycle facility.

OPTIMIZING THE EVACUATION PLANNING FOR THE ROHINGYA REFUGEE CRISIS IN BANGLADESH USING A MULTI-OBJECTIVE OPTIMIZATION TECHNIQUE

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Abstract. This study introduces a location-allocation based evacuation plan for the Kutupalong-Balukhali expansion site, Cox's Bazar, housing Rohingya refugees. Two multi-objective optimization techniques, NSGA-II and WCA, integrated with GIS, are utilized to solve the optimization problem. The objective functions of minimizing travel time and capacity overburden are employed. The study collects data from UNOCHA services and identifies suitable cyclone shelters, schools, and prayer halls as safe evacuation locations. Both algorithms perform well in solving the evacuation problem, with WCA recommended for its solution quality and repeatability, and NSGA-II for providing quick solutions. Multiple optimal solutions are presented to enhance the planning of the evacuation proposal.

Keywords: Location-allocation, multi-objective optimization, GIS, refugee camp, evacuation planning, AMOSA.

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IN-PLANE SEISMIC PERFORMANCE OF PARTIALLY GROUTED REINFORCED MASONRY WALLS

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Abstract. Building Code Requirements and Specification for Masonry Structures (TMS 402) used in USA proposes maximum flexural reinforcement ratio (ρ_{max}) to ensure ductile behavior of reinforced masonry shear walls. However, in certain practical design cases when a wall is under high axial load, this ρ_{max} tends to be lower than minimum or even zero i.e., the wall cannot be constructed following the TMS 402 design provisions. This paper investigates the seismic behavior of three full scale partially grouted special reinforced masonry shear walls (PG-RMSWs) subjected to high axial loads (10,15 and 20%) aiming to evaluate the ductile performance of PG-RMSWs. A test setup was developed to test the walls under quasi-static cyclic loading. The effects of the level of axial compressive stress were studied on the inelastic behavior, damage progression, load-displacement response, extent of yielding in reinforcements and axial strain in the masonry of the three PG-RMSWs. These walls under high axial load showed flexure and flexure-shear behavior and at 20% strength degradation reached a drift of 1.30% to 2.43%. At ultimate capacity, the strains recorded on flexure reinforcements showed yielding at a factor of ≥ four times ε_y and strain in masonry was found to be 2-3 times the design value 0.0025 for all the walls. The paper evaluated these ductile performance parameters and aims to fill the gaps in the literature for partially grouted RMSWs.

Keywords: Reinforced masonry, shear walls, partially grouted, ductility, seismic behavior, cyclic loads, seismic response.

INVESTIGATION OF THE OPEN TIME AND COMPRESSIVE STRENGTH OF ALKALI-ACTIVATED MIXTURES FOR 3D-PRINTED CONCRETE

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Abstract. This study investigates the use of class C fly ash (FA) as a precursor for alkali activated mortar (AAM) for 3D-printed concrete (3DPC). Sodium silicate (SS) and sodium hydroxide (SH) were used as the alkali activators. Three AAMs with different SS/SH ratios (i.e., 0.5, 1.0, and 2.0) were examined to achieve mixtures that can be tailored for 3DPC. The extrudability of the AAMs was evaluated through the open time test. The compressive strength of AAMs in different directions was examined with different cycle times (CTs) of 1.0, 2.5, and 5.0 minutes. The results revealed that the open times of the AAMs ranged from 3.5 to 24 minutes. These open times depend on the ratio of SS/SH, offering flexibility in optimizing the speed of printing for different applications. The 3DPC specimens showed anisotropic behavior compared to those full-height specimens. The compressive strength of the full-height specimens was higher by 1.6-12% and 3.1-17% than 3DPC specimens tested parallel (X-direction) and normal (Z-direction) to the printing directions, respectively. Regardless the tested direction and CTs, 3DPC specimens having SS/SH of 2.0 showed the highest compressive strength compared to those of SS/SH of 0.5 and 1.0. The compressive strengths of 3DPC specimens ranged from 25.2 to 37.6 MPa with increasing SS/SH from 0.5 to 2.0.

Keywords: 3D-printed concrete, Alkali-activated mortar, Class C fly ash, Open time, Cycle time, Compressive strength.