Book of Abstracts

6th International Conference on

Structural Engineering and Construction Management 2015

Kandy, Sri Lanka

11th to 13th December 2015

Abstracts of 6th International Conference on

Structural Engineering and Construction Management 2015

Vision

Promoting innovative research for tomorrow's development

Mission

To meet experts, colleagues and friends in the field and to exchange findings, concepts and ideas on research for the development of a sustainable world

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Preface

It is with great pleasure that we present the Proceedings of the 6th International Conference on Structural Engineering and Construction Management (ICSECM 2015). This is the sixth conference consecutively organized following the 1st International Conference on Sustainable Built Environment in 2010, 2nd International Conference on Structural Engineering and Construction Management in 2011, 3rd International Conference on Sustainable Built Environment in 2012, 4th International Conference on Structural Engineering and Construction Management in 2013 and the 5th International Conference on Sustainable Built Environment in 2014, keeping its tradition of adhering to engineering excellence.

Taking a step forward from the last four events, the coverage of specialty areas of this conference has been diversified. This book contains the abstracts of research papers from ten different sub specialties in Construction Management, Construction Materials and Systems, Structural Health Monitoring, Structural and Solid Mechanics, Earthquake Engineering, Fatigue Damage of Materials, Water Safety, Hydraulic Structures, Tall Building and Urban Habitat and MSW and Landfill Management. We expect that all these abstracts will be presented in parallel sessions from 11th to 13th December 2015.

We would like to express our appreciation to all keynote lecturers for their invaluable contribution. We are very much grateful to the authors for contributing research papers of high quality. The research papers of these abstracts in the publication have been peer-reviewed. The enormous work carried out by the reviewers is gratefully appreciated. We are also pleased to acknowledge the advice and assistance provided by the members of the international advisory committee, members of the editorial committee along with many others who volunteered to assist to make this very significant event a success. Finally, we acknowledge the financial sponsorship provided by many organizations that has been extremely helpful in successfully organizing this international conference.

It is the earnest wish of the editors that this book of abstracts and volumes of proceedings would be used by the research community and practicing engineers who are directly or indirectly involved in studies related to Construction Management.

Editorial Committee

6th International Conference on Structural Engineering and Construction Management 2015

11th December 2015.

Message from
Conference Chairmen

It is a pleasure for us to welcome all the participants to the 6th International Conference on Structural Engineering and Construction Management 2015 in Kandy, Sri Lanka. We, the co-chairs would gratefully like to mention the previous successful conferences, the 1st International Conference on Sustainable Built Environment 2010, 2nd International Conference on Structural Engineering and Construction Management 2011, 3rd International Conference on Sustainable Built Environment 2012, 4th International Conference on Structural Engineering and Construction Management 2013 and the 5th International Conference on Sustainable Built Environment in 2014, all held in Kandy, Sri Lanka.

The theme selected for the conference - Structural Engineering and Construction Management- is extremely relevant for today's world. With the vision of promoting innovative research for tomorrow's development, we organize this conference as a meeting place of talents, knowledge and dedication. Therefore, we trust that the conference will produce great ideas from a variety of Research and exchange the knowledge of experts, colleagues and friends who are working for the world's sustainable development.

The conference focuses on different sub topics in Structural Engineering and Construction Management, Construction Materials and Systems, Structural Health Monitoring, Structural and Solid Mechanics, Earthquake Engineering, Fatigue Damage of Materials, Water Safety, Hydraulic Structures, Construction Management, Tall Buildings and Urban Habitat and MSW and Landfill Management. The proceedings of the conference are peer reviewed. The full papers are published in volumes in paper format with a book of abstracts.

The host city of the conference, Kandy, is a world heritage city famous for its unique architecture, culture, natural beauty and climate. We hope that you will enjoy your time in Kandy during the conference.

We, the conference co-chairs express our sincere thanks to our guests, keynote speakers, authors, members of the international advisory committee, members of the editorial committee financial sponsors and many others who volunteered to assist to make this very significant event a success.

Prof. Ranjith Dissanayake
Prof. S.M.A. Nanayakkara
Prof. Priyan Mendis
Prof. Janaka Ruwanpura
Dr. Y.G.S. De Silva
Eng. Shiromal Fernando

Co-chairs

6th International Conference on Structural Engineering and Construction Management 2015
11th December 2015.

Message from
Vice Chancellor, University of Peradeniya

I am pleased and privileged to forward this message as the Chief Guest on the occasion of 6th International Conference on Structural Engineering and Construction Management (ICSECM–2015) to be held on 11th December 2015. I am sure that this conference will create a platform for local and international participants to share their experiences and exchange new knowledge and the recent development in the field of structural engineering and construction management. Giving a serious thought to pursue in advance research in this field is very essential because it is the duty and responsibility of the individuals associated with this profession to prepare their members to take up leadership positions in structural engineering & construction management with special emphasis in massive and complex structures which have become increasingly common in the present day world.

I understand that the ICSECM – 2015 is a joint venture of a number of professionals, institutions and specially the Universities of Peradeniya, Moratuwa and Ruhuna. While congratulating the Organizing Committee of the ICSECM 2015, I convey my very best wishes to make this event a grand success.

Prof. Upul B. Dissanayake

Vice-Chancellor
University of Peradeniya,
Peradeniya,
Sri Lanka.

Message from
Dean, Faculty of Engineering, University of Peradeniya

I am glad to submit this message for the Sixth International Conference on Structural Engineering and Construction Management (ICSECM-2015), which is a continuation of the efforts of the organizers to share knowledge and research in the sectors. This time too, the conference is held in historic city of Kandy, in Sri Lanka.

The ICSECM - 2015 is organized as a joint effort of a number of professionals, and a number of institutions; including Engineering Faculties of Peradeniya, Moratuwa and Ruhuna Universities in Sri Lanka. The topic covered and the keynotes delivered by professionals in the field add more depth to the objectives and outcomes of the conference.

I take this opportunity to thank the organizers for their commitment and persistent effort to make the conference a success. These events facilitate a forum for many young undergraduate and postgraduate students to receive a good initial exposure to present their work, and for some few, to get a flavor of organizing events of global importance.

I believe that the organizers of ICSECM-2015 will continue their dialog of bringing concerned professionals from diverse fields, from different parts of the worlds, into the discussion forum of ICSECM.

I wish the conference a great success.

Prof. Leelananda Rajapaksha

Dean,
Faculty of Engineering,
University of Peradeniya,
Peradeniya,
Sri Lanka.

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SECM/15/001

A STUDY OF EXPERIMENT IN ARCHITECTURE WITH REFERENCE TO PERSONALISED HOUSES

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Abstract:
This research is an enquiry into architectural design and construction. It is an examination on how architects experiment and innovate. Research identifies 'design intervention' as the critical and profound feature common to Sri Lankan architecture. Having established that, the question arises as to 'why' this 'richness' has not extended into interventions with building materials and technology? This leads to two key hypotheses; "Architects are not sufficiently involved in experimenting with building material and technology" and "the limited experimenting is due to cost issues".

The research looks at the architecture of personalized houses designed by Chartered Architects in Sri Lanka. This sector receives the most active contribution from the professionals but the approaches are confined to a limited set of practice conventions. Therefore, this segment of the industry is identified as the most appropriate the carry tout the research.

The research is carried out according to a theoretical framework formulated in relation to materials and technology. The study investigates the effects of 'cost' in relation to experiment and attempts to establish the notion of 'experiment' in architectural design process and practice in Sri Lanka.

Keywords: Experiment in Architecture, Materials and Technology, Building Process, Conventions, Cost

SECM/15/004

IDENTIFICATION OF SIGNIFICANT FACTORS INFLUENCING PERFORMANCE OF ROAD CONSTRUCTION INDUSTRY USING FACTOR ANALYSIS

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Abstract:
This study is aimed at identifying the significant factors affecting the performance of road construction projects in Sri Lanka using factor analysis. Data collected using a questionnaire distributed among thirty engineers working in the road construction industry in Sri Lanka who represent the engineer and the contractor organizations. A list of 130 factors influencing performance of road construction industry have been identified & included in the questionnaire and all thirty engineers responded and returned the questionnaire. Participants were requested to allocate marks from 1-5 (1-very poor influence; 2-poor influence; 3-average influence; 4-high influence; 5-very high influence) to each factor according to their knowledge.

Factors influencing performance of the road construction contracts have been ranked based on average score initially. Significant factors influencing the performance have been identified using factor analysis and they were: conducting progress review meetings and site inspections at appropriate intervals; previous experience of the construction team working on similar project; effective monitoring and feedback by the construction manager; availability of skilled construction labour; engineer's ability to analyze contractor's claims fair and reasonable manner; making payment for Interim Payment Certificates within reasonable time (2 weeks); quick response by the contractor to employers and engineer's requests and instructions; certification of the Interim Payment Certificates by the engineer within a reasonable time (2 weeks) and timely submission of the Interim Payment Certificates by the contractor.

Keywords: Construction, Factor Analysis, Industry, Performance, Roads.

SECM/15/006

SIMPLIFYING WATER SAFETY PLANS

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Abstract:

"A number of studies in recent years have shown that significant gastro intestinal disease could be attributed to consumption of water that (even) met standards for coliforms and E.coli when tested. As a result, the water sector is moving away from simple water testing and towards risk assessment and management. WEDC Recognizing this, The World Health organization, had compiled a Water Safety Planning manual for Community water Supplies giving guidance on step by step risk management approach, which works in the manner of several defense lines. Though comprehensive and with a lot of checklists, it needs presentation in a more user friendly form, in order to be used by a wider audience it is meant for. Recognizing this opportunity, tables of checklists of the manual have been put together in a logical order and presented in a poster fashion, keeping the original content, using fonts and colours, making it attractive and readable to the viewer. New ideas too have been included from the Srilankan context- a) Health risks due to dehydration of body cells caused by insufficient consumption of water at all times, b) Health risk due to consumption of Reverse osmosis water of very low mineral content . The WSP approach is a tool not merely to provide "safe" water, but to meet a higher objective of boosting the immunity of the human organism, not compromising it, by the attempt to provide waters devoid of all microbial activity.

Keywords: Water Safety Plan, Risk Assessment, World Health Organization

SECM/15/009

SEISMIC EVALUATION OF A LOW-RISE REINFORCED CONCRETE COMMERCIAL BUILDING BY THE CAPACITY SPECTRUM METHOD

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Abstract:
This paper presents seismic evaluation of a typical low-rise reinforced concrete commercial building based on the capacity spectrum method (CSM) recommended in ATC-40. A nonlinear three-dimensional finite element (FE) model is developed for assessing the seismic capacity of the structure. To simulate a more realistic behavior of the building during ground motions, effects of foundations, masonry infills, and other site-specific features are integrated into the model. Seismic capacity of the structure is determined using pushover analysis and compared with the demand imposed by predicted ground motions. Results indicate that this building possess the most undesirable brittle failure with low level of seismic capacity. Further, this analysis method reveals several earthquake vulnerable features and the effectiveness of 3D modeling of buildings with strength and stiffness irregularities. Finally, design recommendations for eliminating earthquake vulnerable features are proposed. However, the typical details used at the foundation-superstructure connection limits the structural system seismic capacity.

Keywords: Capacity Spectrum Method, Building, Earthquake Vulnerability, Pushover Analysis, Soft-Story.

SECM/15/010

CLUSTERING TECHNIQUES AND ARTIFICIAL NEURAL NETWORK FOR ACOUSTIC EMISSION DATA ANALYSIS

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Abstract:
Acoustic emission (AE) sensor technology is commonly used for real-time monitoring of fatigue sensitive details. This is mainly due to its ability to detect fatigue events (crack initiation and opening) by mounting sensors in the vicinity of potential crack location. Also, AE data can be used for damage location detection. Even though AE provides many capabilities with regard to fatigue monitoring, many implementation challenges exist. A majority of the challenges is associated with noise elimination, AE signal analysis, and interpretation of the results. This article describes AE implementation for monitoring a fatigue-sensitive detail and use of data analysis techniques such as cluster analysis, non-linear mapping (NLM), and three-class classifiers to identify the relationship of each cluster to the characteristics of crack opening signals, background noise, and structural resonance.

Keywords: Acoustic Emission, Artificial Neural Network, Cluster Analysis, Data Analysis, Fatigue Monitoring.

SECM/15/011

TEMPORARY SUBSTRUCTURE FORCES DURING BRIDGE SLIDE: IMPACT OF SLIDING FRICTION AND SUBSTRUCTURE ALIGNMENT

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Abstract:
Slide-in Bridge Construction (SIBC) is different from the conventional bridge construction because of the activity required to move the bridge to final position following construction. Moving activity requires bridge to be on a temporary support structure, resting on a sliding system such as bearings suitable for sliding, and a system of force actuation for pushing or pulling the bridge. Two SIBC projects were recently completed in Michigan, USA. SIBC being new to the bridge community, substructure forces that are developed during slides are best estimated. Hence, one of the Michigan projects was selected and slide operation was simulated using dynamic explicit finite element analysis techniques. This article presents use of dynamic explicit finite element analysis for evaluating temporary substructure forces during bridge slide. Further the analysis results are used to explain the impact of unequal friction at sliding surfaces and differential alignment of the temporary supports on substructure forces and bridge superstructure movement. Typically, bridge superstructures are slid in place using force-controlled systems. Analysis was performed using force-controlled and displacement-controlled methods. Then, the analysis results are used to explain the benefits of using displacement-controlled methods with force monitoring to slide a bridge rather than employing a force-controlled method.

Keywords: Accelerated Bridge Construction (ABC), Dynamic Explicit Simulation, Finite Element Analysis, Parametric Analysis, Slide-In Bridge Construction

SECM/15/014

DESIGN OF THE NEW EXTRA-DOSED BRIDGE OVER THE KELANI RIVER

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Abstract:
An extra-dosed post-tensioned pre-stressed concrete box girder bridge over the Kelani River is scheduled to be built as part of an elevated roadway project in Colombo, Sri Lanka. This three-span structure will be 380m long, with a 180m main span. The box-girder will be 5.6m high at the pylon locations and 3.3m at mid-span and the ends. The two U-shaped pylon structures with a twin tower configuration will support a fan-type stay-cable arrangement with 24 stay-cables emanating from each tower. The towers which are 29m high, rise from the piers starting at the level of the under-side of the pot-bearings supporting the box girder. The stay-cables are attached to the 30.4m wide bridge deck at the sides and are proposed to be ECF cables. The detailed design of the bridge was carried out taking into consideration the in-situ balanced cantilever method of construction, which will be used for this bridge, through a staged analysis. The design was carried out in conformance with BS5400. Structural modelling and analysis was carried out using the CSiBridge2015 software. This paper presents and discusses the detailed design procedure of the main bridge elements, the load-cases considered, key results and the planned construction procedure of the proposed bridge

Keywords: Balanced-cantilever, Extra-dosed, Staged construction analysis

SECM/15/015

OUTLINE OF THE NEW CONSTRUCTION PROJECT OVER THE KELANI RIVER

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Abstract:
This project is to construct part of urban expressway in the most congested area in Colombo, Sri Lanka. It is featured by a long-span prestressed concrete extradosed bridge and elevated steel box girders supported by steel portal frame piers. This paper presents outline of the project by focusing on the advancement of technologies employed in this design, construction method and long-term durability.

Keywords: High performance steel, epoxy coated and filled strand, extradoses bridge, accelerated construction, gravel compaction, urban elevated steel bridge

SECM/15/024

ANALYSIS OF STRAIN RATE DEPENDENT TENSILE BEHAVIOUR OF POLYURETHANES

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Abstract:
The stress-strain behaviour of elastomeric polymers, such as polyurethane (PU), exhibit high rate dependency, stress–strain non-linearity, and high pressure dependency when compared to other construction materials. Since these polymers exhibit the potential to be applied as retrofitting and protective material for various types of structural materials, in enhancing their load-carrying capacity, ductility and structural survivability under different loading regimes, it is essential to comprehensively investigate their mechanical behaviour at varying strain rates. This study was undertaken to investigate the tensile stress-strain characteristics of elastomeric PU at varying strain rates, ranging from 0.001 s-1 to 0.1 s-1 (low to intermediate). The primary emphasis of this study was on the strain rate sensitivity of the tensile properties, including the Young's modulus, tangent modulus, ultimate tensile stress, fracture strain, and strain energy modulus. The findings indicated that stress-strain behaviour of the PU exhibited high dependence to variations in strain rates and stress–strain non-linearity. The behaviour of PU also provided good concurrence with recent studies, which explored the strain rate dependency of other elastomeric polymers.

Keywords: Dynamic loading, Polyurethane, Strain rate, Stress-strain behaviour, Tensile behaviour.

SECM/15/025

WATER POLLUTION IN A NATURAL STREAM AND ITS IMPACTS ON SOCIETY AND ENVIRONMENT: A REVIEW OF STUDIES ON *MEDA ELA*, SRI LANKA

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Abstract:
Meda Ela which originates from *Kandy* Lake and runs through *Kandy* city is considered to be one of most polluted tributaries of *Mahaweli* River. The objective of the study was to critically review the published research findings related to *Meda Ela* pollution to existing problems, research gaps and the means to rectify the situation. The review was carried out under the categories of socio-economic background, land use changes, sources of pollution, solid and waste water disposal, water quality, cost due to water pollution, economic benefits and major stakeholders and their interactions of *Meda Ela*. Study identified a very high urbanization rate in the watershed during the last decade compared to previous 30 years. Major point sources include the hospital, bus stand, railway station, central market and the residences on either side of *Meda Ela*. According to the literature, elevated pollution levels are reported during wet season and NO^-_3, NH^+_4, PO^{3-}_4, suspended solids, heavy metals, DO, BOD and COD showed above threshold limits. This is an indication of non-point source pollution which is responsive to hydrological conditions. Impacts of water pollution include vector borne diseases such as *Dengu* and *Chickengunya*, bad odour, flash floods and contamination of shallow groundwater with heavy metals. The social and management setup in the watershed is very complex since many stakeholders are involved in polluting and managing *Meda Ela*. The analysis revealed that the relationship among different stakeholders is highly diverse and as a result, their contribution to control water pollution in *Meda Ela* is also very different. Hence, a strong connection should be established between community and other stakeholders to develop an efficient and effective management plan to safeguard *Meda Ela* stream and its watershed.

Keywords: Black water and Grey water, Biological indicators, Dissolves oxygen, Ethnic groups.

SECM/15/028

SYNTHESIS OF ULTRA-HIGH PERFORMANCE CEMENTITIOUS COMPOSITE INCORPORATING CARBON NANOTUBES

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Abstract:
Ultra High-Performance Concrete (UHPC) is a type of special concrete developed to meet the demand for niche applications in the industry, where this type of concrete comes with enhanced durability and superior mechanical characteristics in comparison to conventional normal- and high-strength concrete. However, UHPC has its drawbacks in terms of lower tensile strength ratio and brittleness. Nanomaterials such as carbon nanotubes (CNT) with their superior mechanical properties are potential candidates to act as nano-reinforcement in Ultra High-Performance Cementitious Composite (UHPCC) matrix, to create a more denser and ductile UHPCC system. However, prior to arriving at the "desired" UHPCC mix design, attention has to be paid to the process of dispersing the CNT into the fresh composite mix since the dispersion of CNT in cement-based material is a challenge due to their agglomerating behaviour. This paper presents on the synthesis of UHPCC mix design which optimizes on its packing density of its constituent materials. The influence of different dispersion methods of CNT on the mechanical strength and microstructure of UHPCC are also reported. It was found that samples reinforced with CNT exhibit higher compressive and tensile strengths and denser microstructure compared to control samples without CNT.

Keywords: Carbon nanotubes (CNT); Ultra High-Performance Cementitious Composites (UHPCC); Mechanical properties; Microstructure; Nano engineered

SECM/15/029

THE SIGNIFICANCE OF BUILDING INFORMATION MODELLING TO THE QUANTITY SURVEYING PRACTICES IN THE UAE CONSTRUCTION INDUSTRY

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Abstract:
Quantity surveying is a significant discipline in the construction industry. Building Information Modelling (BIM) was defined at early stages as the development of Computer Aided Design (CAD). BIM has been developed and it has the potential to revolutionize construction process in the way how buildings are designed, analyzed, constructed and managed. Several disciplines including quantity surveying profession are being extensively impacted by the emergence of BIM. The quantity surveyors' roles in construction include a wide range of services. BIM offers numerous advantages to the quantity surveying practices. However, BIM adoption level in quantity surveying practice is comparatively less due to some of its current limitations and challenges. The aim of this paper is to investigate the effectiveness of BIM adoption in quantity surveying practices in the UAE. The secondary data was collected through a critical literature review and whilst empirical data was collected through semi-structured interview and online questionnaire survey among the quantity surveyors in the UAE. It is highly recommended that the implementation of BIM in quantity surveying practices in the UAE is beneficial and would generate great opportunities for the development of the construction industry. It is also suggested that the uptake of BIM is more effective to survive in the competitive construction market.

Keywords: BIM, Quantity Surveying Practices, UAE Construction Industry

SECM/15/031

COMPREHENSIVE RISK ASSESMENT AND RISK MANAGEMENT IS EFFECTIVE TOOL OF CONSISTENTLY ENSURING THE SAFE DRINKING WATER IN COLOMBO METROPOLITANT AREA AND THEIR SUBURBS

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Abstract:
Colombo is the largest economic and tourist attractive city in Sri Lanka, situated geographically at 127 degree 30' E longitude and 37 degree 00' N latitude. The city is spread over 37.3 km^2 and its present population is 5.6 million in Colombo district .City administration is governed by Colombo Municipal Council with sub units in suburbs of Colombo.

The drinking water supply is managed by the National Water Supply & Drainage Board (NWS&DB). It's responsible for operating water treatment plants, safe storage and distribution of drinking water to consumers.

Quality of the drinking water is customer satisfaction, therefore to ensure the customer satisfaction, not only the treated water quality – SLS 614: 2013 – but also raw water quality has to be monitored within SLS 722: 1985.KelaniRiver is the main drinking water source for 80 % population from Colombo and this river provides 700,000 m^3 /day raw water to the water treatment plants in Ambatale and Biyagama.

NWS&DB continue monitoring the raw water quality of Kelani river taking samples of selected locations to test selected water quality parameters.The purpose of testing the water quality in production centres and distribution system is to supply good quality drinking water achieving economic development with a healthy nation. Therefore NWS&DB has laboratory network in Colombo district to test physical, chemical and microbiological parameters in potable water according to SLS 614: 2013. Around 600 numbers of samples are taken monthly from distribution system to ensure microbiological quality of the drinking water.

Water quality monitoring is reactive attitude rather than preventive,field investigation revealed that any action and activity that is required to prevent or eliminate hazards.Therefore risk assessment, risk management and control measures are required to ensure the quality of drinking water to achieve health base targets.

Key words: Risk management, Risk Assessment, Hazards, Control Measures

SECM/15/032

A STUDY ON WATER MANAGEMENT STRATEGIES PRACTICED IN HEALTHCARE FACILITIES IN SRI LANKA: A LITERATURE REVIEW

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Abstract:
Water management in facilities can be simply explained as consuming water effectively without obstructing the functions of the facility. Healthcare facilities are one of the major types of facilities which consume a huge amount of water for their daily operations. Therefore, water management in healthcare facilities should be given a special attention in order to reduce the operational cost of the facility while contributing to sustainable development of the country. Various strategies can be practiced for water management in healthcare facilities and the understanding on current water management practices is important to take necessary measures to improve the current practices. The aim of this research was to investigate the current water management practices of healthcare facilities. Hence, a comprehensive literature review was carried out to identify the water management practices of healthcare facilities. The identified strategies could be categorized in to two as general water management strategies and strategies which are specific to healthcare facilities. Application of these strategies enable the management of healthcare facilities to minimize the drawbacks of their current water management practices and reduce the water consumption of their facilities by a considerable amount.

Keywords: Healthcare Facilities, Strategies, Water Management

SECM/15/035

CONSTRUCTION OF CONSISTENT MASS SPRING MODEL BASED ON META-MODELING THEORY FOR SEISMIC RESPONSE ANALYSIS OF LARGE SCALE BRIDGE STRUCTURES

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Abstract:
Meta-modeling theory is aimed at constructing a set of analysis models which are consistent with continuum mechanics or a solid element model. This paper presents a consistent mass spring model (CMSM) of a large scale bridge structure, which is constructed according to the meta-modeling theory to make efficient seismic response analysis. The CMSM shares the same dynamic characteristics as the solid element model and can be used to study fundamental seismic responses for a complicated large scale bridge structure that consists of piers and decks. In the numerical experiment, time history analysis is made for six different bridge structures. Full comparison is made for a CMSM and a solid element model of these six bridge structures, and it is shown that the CMSM is able to estimate the dynamic responses such as displacement and base shear for a certain class of ground motions.

Keywords: bridge structure, consistent modelling, continuum mechanics, mass spring model, structural mechanics.

SECM/15/037

FEASIBILITY OF USING PALMYRAH AND BAMBOO STRIPS AS REINFORCEMENT IN LINTELS

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Abstract
Timber species such as Palmyrah, Bamboo and Babadua have been identified to have potential to replace reinforcing steel in concrete elements. This research was conducted to assess the feasibility of using Palmyrah and Bamboo strips as reinforcing material in lintels. The low ductility of such timber specimens, as observed during the experiments, governed this selection of a lightly loaded low risk structural element for the study. Tensile strength, water absorption and desorption characteristics, associated dimensional variations, anchorage bond strength and flexural strength of Palmyrah and Bamboo strips coated with different water repellents were evaluated using a series of laboratory experiments. Having identified double varnish coated water repellent technique to give the highest anchorage bond strength and lowest water absorption, four lintels were cast keeping two as unreinforced control specimens and two reinforced with Palmyrah and Bamboo strips. While both reinforced beams exhibited under-reinforced behaviour, one with Bamboo reinforcement achieved an incremental moment capacity of 250% and the beam with Palmyrah reinforcement achieved that of 168% compared to their respective unreinforced beams. Hence, it was concluded that both Palmyrah and Bamboo shows potential to be used as reinforcement for lintels.

Key Words: Timber Reinforcement, Bamboo, Palmyrah, Lintel

SECM/15/038

AN EXPERIMENTAL INVESTIGATION ON THERMAL PROPERTIES OF IMMATURE CONCRETE

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Abstract:
Since the heat of hydration of cement is highly temperature dependent, variation of thermal properties of concrete at early ages is essential to predict the temperature rise and distribution due to heat of hydration of cement in concrete. Experimental investigation was carried out to obtain the temperature response of fresh concrete sample of 150mm cube with time under known thermal boundary condition. The specific heat capacity of fresh concrete was estimated based on the specific heat capacities of cement and products of cement hydration using Dulong – Petit Rule (DPR) and Neumann– Kopp Rule (NKR). The thermal conductivity (λ) was determined by fitting the temperature response curve of the cube with the temperature history predicted by transient heat conduction analysis based on the estimated specific heat capacity of concrete using ANSYS software. Tests were conducted for concrete at early age, i.e. from one hour to 1 day, for several mix proportions. It was found that thermal conductivity increases rapidly within the first 5 to 12 hours and reached a constant value which depends on the mix proportion.

Keywords: thermal conductivity, specific heat capacity, early age concrete, transient heat conduction analysis

SECM/15/041

CONCEPT FOR SEPARATION OF DIFFERENT WASTEWATER STREAMS IN ORDER TO MINIMIZE EMERGING CONTAMINANTS IN DRINKING WATER

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Abstract:

In the recent past trace levels of many contaminants were reported in drinking water. Substances that are resistant to bacterial degradation will flow along with treated effluent and will end up in inland surface waters from which raw water is extracted for public water supply systems. In certain extreme situations, presence of excessive concentrations of these contaminants can inhibit bacterial degradation of biological wastewater treatment processes. Therefore there is a natural tendency for build-up of these contaminants in water sources. The emerging contaminants found in drinking water are heavy metals and hazardous substances that flow along with industrial effluent, hospital effluent and agricultural runoff.

In order to remove these substances that are resistant to biological wastewater treatment, it is recommended to separate them in concentrated form by a separate collection system without allowing to mix with other wastewater streams.

For wastewater other than domestic nature containing heavy metals, residual dies etc. and hazardous wastewater generated from hospitals such as radioactive iodine treatment for cancer patients, chemicals used for X Ray processing, Amalgam used by Dentists to fill up cavities , Antibiotics, Laboratory chemicals such as Salicylic Acid, Benzoic Acid, Ethidium Bromide (used for molecular biology research), Xylene, Formalin for preserving biological specimens, etc. must be separated in concentrated form in a separate collection system without mixing with wastewater of domestic nature and disposed after treatment as hazardous wastewater. As per the "Policy on siting of high polluting Industries " it is not possible to locate industries that are categorized as Type "A" high polluting industries upstream of intakes that extract raw water to produce potable water supply as it is very difficult remove these substances by conventional water treatment techniques

Key words: Emerging contaminants, Hazardous wastewater, Wastewater separation

SECM/15/042

LABORATORY PERMEABILITY TESTING OF GRANULAR SLAG AND GRAVEL SUB BASE COURSES (GSB)

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Abstract:
Granular Sub Base Course (GSB) provided as one of the structural layer of pavements should also serve as an effective drainage layer. In India current guidelines recommend using natural sand, crushed gravel, stone or slag or combination of these, in the GSB layer. While the above combinations may fulfil the structural requirement, it is not clear whether they meet the minimum drainage requirements of 300 m/day as per AASHTO specifications.

This paper summarizes the laboratory permeability carried out on 1) Crushed stone aggregates and slag in different combinations with non-plastic fines such as quarry dust and 2) Gravel-Aggregate combination in the ratio 60:40. The first combination was tried for Grade III requirements as per MORT&H specification (5th Revision) for High volume roads. The second combination was tried for Grade III requirements as per rural roads Manual, IRC SP 20, used for low volume roads in India.

The objective is to compare the permeability characteristics of GSB gradations prepared with different mixes in order to assess their ability to drain, based on the permeability criteria. Horizontal and vertical permeability were tested in the laboratory for these GSB mixes and the results have been reported.

From the study it is observed that while all the combinations of crushed stone – slag mixes meet the minimum permeability criteria in the horizontal as well as vertical directions, 100% granulated steel slag (GLDS) does not meet the requirement in the vertical direction. Also while the Gravel – Aggregate combination (60:40) just meets the minimum permeability requirement in the horizontal direction, there is negligible discharge in the vertical direction.

Keywords: permeability, quarry dust, slag, gravel, horizontal, vertical

SECM/15/043

DETERMINATION OF BINDER FILM THICKNESS FOR BITUMINOUS MIXTURES PREPARED WITH VARIOUS TYPES OF FILLERS

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Abstract:
Roads form the lifeline of any country. It is considered to be an engineered structure and the pavement is expected to serve its designed life and meet the performance criteria for better economy. Various materials constitute the different layers of the pavement and their characterization becomes important for durability. In spite of these considerations however, many factors contribute to early pavement failure and improper material characterization is just one of them. The Bituminous mix which is used for the surface and binder courses is formed as a conglomeration of the binder, graded aggregates and voids which forms a stable mixture which can resist wear and tear as well as heavy wheel loads when used in the field. The bituminous mix needs to meet the volumetric requirements to attain stability. When bitumen is mixed with aggregates in a heated condition, the binder forms a coating around the aggregate particle which is termed as Asphalt film thickness (AFT) which is not measured but calculated. Bitumen due to its visco-elastic nature should be used at the optimum and the specified temperature to provide a minimum uniform film thickness to ensure proper bonding in the Bitumen mastic. Fillers play a major role in determining the properties and the behaviour of the mixture, especially the binding and aggregate interlocking effects. The filler has the ability to increase the resistance of particle to move within the mix matrix and/or works as an active material when it interacts with the asphalt cement to change the properties of the mastic. Mineral fillers serve a dual purpose when added to asphalt mixes, the portion of the mineral filler that is finer than the thickness of the asphalt film blends with asphalt cement binder to form a mortar or mastic that contributes to improved stiffening of the mix.

In the present study the film thickness was determined by Hveem method by determining the total surface area and the effect of fillers thereon is discussed. The effect of types of fillers in varying percentage, in the performance of hot-mix-asphalt is also studied. Three types of fillers namely, Hydrated lime, Ordinary Portland Cement, and Fly ash were used as fillers in the present study. Their percentage by weight of aggregates was varied as 2%, 4% and 6% to study their effect on the mix prepared for BC Grade II. The optimum binder content was determined for the various fillers and moisture susceptibility of bituminous mixtures was evaluated. The results of film thickness determination reveals that an average film thickness of 6 μm is obtained for all fillers which is necessary for durability of the mixes. The Fatigue results show that Lime at 4% can be used for enhanced performance and 2% is recommended, when cement or fly ash is used as filler material.

Keywords: Asphalt Film thickness, Volumetric properties, Aggregate surface area, Stone binder interaction, Durability, Fillers

SECM/15/044

SUSTAINABLE APPROACHES TO THE MUNICIPAL SOLID WASTE MANAGEMENT IN SRI LANKA

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Abstract:
Municipal solid waste (MSW) is a serious environmental & socioeconomic issue in Sri Lanka and Haphazard disposal, population growth, migration and rapid urbanization will accelerates the issue further. Comprehensive and accurate measurement of waste generation and disposal continues to be an issue at national, provincial and local levels. The present composition of solid waste collection by the Municipal Councils 49.5% (1,696 Mt), Urban Councils 17.4% (594.5 Mt) and "Pradesiya Saba" Areas 33.1% (1,133 Mt). Conversely, through the several government and non- government projects were operating towards the National Solid Waste Management (NSWM). Further they were have been conducted the analyses for their internal use. However, there is no proper mechanism to coordinate this information and research, or to compile results with an intergraded approach. Appropriate estimations and evolutionary predictions will sustain new projects by minimizing difficulties. Previous data were shows approximately MSW is contain 50 - 65% readily bio-degradable waste or organic component and the balance is inorganic component. Low calorific values recoded in organic fraction of waste and it is possible to use as raw material of composting or bio-gas generation. And the receiving part of the waste should be running through the material recovery facility (MRF) and the residue has to incinerations and finally to landfilling. With the current situation there is a possibility of earning 20-22 US$ from a one metric ton of mixed MSW. There is no proper focus into the Cleaner Development Mechanism (CDM) to the current MSW management project as well as there is no focused in to Intergraded Solid Waste Management (ISWM) in the country. This paper suggested that the importance of ISWM by maintaining a sustainable composite mechanism through locally – available materials and expertise, with evidence based approach planning and strategy through eliminating the potential risks to provide a clean, healthy pleasant living environment and resource management culture for current and future generations of Sri Lanka.

Keywords: Municipal Solid Waste, Intergraded solid waste management, Material recovery facility, Cleaner Development Mechanism, locally – available materials and expertise.

SECM/15/045

APPICATIONS OF ENVIRONMENTALLY FRIENDLY CELLULAR CONCRETE IN CONSTRUCTION

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Abstract:
Cellular concrete is a cost effective construction material that is continuously gaining traction and popularity in the US and elsewhere. Cellular concrete is a material consisting of Portland cement, water, and foam. When it hardens, the concrete has an oven-dry density ranging from approximately 50 lbs/cubic feet to 90 lbs/cubic feet. Some applications have achieved an even lower density that 50 lbs/cubic feet. Recipes may also include aggregates such as fly ash. Admixtures are used as well depending on the final use of the product. Cellular concrete has numerous applications in the building construction industry and as an underground backfilling material, but lately other uses in the infrastructure field have been gaining popularity especially as a stabilizer around transmission conduits. Popular application of cellular concrete includes insulation, fire retarding, and sound proofing for a variety of structures. Cellular concrete systems provide better drainage, increased fire resistance, increased wind uplift ratings, improved seismic values, efficient thermal insulation, and improved sound attenuation in an environmentally friendly manner. In underground applications, cellular concrete is used as a cost effective filler material in lieu of soil without the compaction effort required when using soil. Most recently the infrastructure field introduced cellular concrete as a backfill and filler material around underground structures such as segmental tunnel liners and pipelines. Cellular concrete can be used as backfill material at pipeline fault crossing by allowing localized ground deformation without overstressing the pipe section. This application can minimize damage to the pipeline or tunnel transmission structure that results from a shear failure of the pipe. However, the low compressive strength of cellular concrete limits its application as a structural material. The paper discusses material behavior and characteristics, state of the art construction methods, and advantages and disadvantages of using cellular concrete as a construction material in current times.

Keywords: Cellular concrete, fire resistance, green roofs, pipeline backfill, thermal insulation, tunnel annular space backfill.

SECM/15/047

COMPARISON ON DISPOSAL STRATEGIES FOR CLINICAL WASTE: HOSPITALS IN SRI LANKA

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Abstract:
Clinical waste is potentially dangerous because it may contain waste resulting from medical, nursing, dental, pharmaceutical, skin penetration or other related clinical activity. Therefore, it is important to exercise special caution in the management of clinical waste in order to minimize its potential danger to public health and environment. Hence, this research intends to conduct preliminary study on clinical waste management practices with special emphasis to disposal strategies and associated cost. Six case studies, both public and private hospitals were used to collect data covering nineteen semi-structured interviews. Findings revealed that the highest and the least clinical waste generated were infectious and pharmaceutical waste respectively. The cost effective disposal strategies were diesel incinerators (Rs. 28.22 per kg) and dispose in a land (Rs.12.50 per kg). In general, cost for disposal of clinical waste in public sector hospitals were Rs. 84,084.22 per day while private sector hospitals were Rs. 42,101.89 per day. Negligence of the worker's safety and issues from the outsourced companies, were the common and critical challenges for both private and public hospitals.

Keywords: Clinical waste, Clinical waste management, Cost, Disposal strategies, Hospitals.

SECM/15/048

MANAGEMENT OF WASTE DERIVED DUE TO CONFLICTS IN THE CONTEXT OF POST CONFLICT RECONSTRUCTION

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Abstract:
Increase of man-made conflicts around worldwide has created conflict waste as a major challenge. Improper management of conflict waste creates issues in public health and safety, environment, economic cost on already strained communities and post conflict reconstruction. End of three decade lasted civil war in the country has created significant amount of conflict waste affecting post conflict reconstructions. Hence, this research was mainly focused on identifying the impact of conflict waste on post conflict reconstruction with special emphasize for Construction and Demolition (C&D) waste. Five organizations involved in post conflict reconstruction in conflict areas were selected as the cases and semi structured interviews were conducted to gather data. The collected data was analyzed using content analysis. It was revealed that, lack of capacity to handle an enormous quantity, difficulty in estimating the quantity and composition, identifying dumping sites, coordination among different parties' involved, financial incapability, and lack of technical peoples as major challenges related with management of conflict C&D waste during post conflict reconstructions.

Keywords: Conflict waste, C&D Waste, Post Conflict, Reconstruction

SECM/15/049

SOCIOLOGICAL ANALYSIS OF STRATEGIES TO BE USED IN IMPLEMENTING OF WATER SAFETY PLANS IN PLANTATION SECTOR – A CASE STUDY FROM FAIR FIELD ESTATE IN NUWARA-ELIYA DISTRICT

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Abstract:
The Water Safety Plan is the assessment, prioritization and continuous management of risks to water safety from catchment to consumer.1 Water Safety Plan is important to obtain sustainable water management through community participation. The objective of this paper is to identify the strategies to implement the WSP in Plantation Sector and to identify the knowledge on WSP among plantation community. Plantation community tend to lack of capacity for sustainable management of water resources due to several reasons. The study highlights that the challenges on implementing Water safety plan in Plantation Sector. This research study intends to utilize both quantitative and qualitative data. In this way, the essential data for this study gathered by using following methods such as personal observation, case studies. The result reveals that lack of awareness, lack of education, lack of community participation, workload, decisions of estate management are few causes which impact on the protection of water resources. Major water sources are located and they are flowing through the plantation sector. However, almost all the people living in the plantation sector are unaware of protecting of water sources in a most sustainable manner; therefore, there is a necessity to implement WSP in Plantation Sector through community mobilization process. It's difficult to target national level water safety strategies to apply in plantation sector, therefore, it is strongly recommended to the relevant authorities to formulate new strategies to implement the Water Safety Plan in Plantation Sector.

Key Words: plantation sector, water safety plan

SECM/15/050

COMPARISON OF FAILURE MECHANISMS OF COASTAL STRUCTURES DUE TO THE 2004 INDIAN OCEAN AND 2011 TOHOKU TSUNAMI EVENTS

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Abstract:
By analysing and comparing the results of post-disaster field studies and literature regarding the mechanisms by which coastal structures failed due to the 2004 Indian Ocean Tsunami and the 2011 Tohoku Tsunami events (the focus being on defence structures where applicable), trends were identified and examined. This paper highlights the most commonly occurring / major failure mechanisms identified in the various locations affected by the two tsunami events. The failure modes found in over twenty locations throughout the Fukushima, Iwate and Miyagi Prefectures of Japan were categorised into seven failure modes: a) leeward toe scour, b) crown armour failure, c) leeward armour failure, d) parapet wall failure, e) overturning, f) seaward toe scour, and g) sliding. Leeward toe scour was found to be the major failure mechanism in seawalls and dikes, and sliding was found to be the major failure mechanism in concrete breakwaters. The failure modes found throughout regions affected by the Indian Ocean Tsunami were categorised into five failure mechanisms: a) scouring of foundations, b) beam /column failure, c) joint failure, d) wall failure, and e) total disintegration. The 'total disintegration' caused by seismic forces, debris collision and hydrodynamic forces was the major failure mode throughout the studied regions. Some of the major tsunami induced forces found to have been among the causal factors of structural failure included hydrostatic and hydrodynamic forces. Flow velocities as high as 13.4 m/s were found in areas of Japan, and flow velocities of up to 10.4 m/s were found in regions affected by the 2004 Indian Ocean Tsunami. Potential strengthening measures were suggested for structures such as seawalls and coastal dikes, which were most vulnerable to scouring at the toe. By producing armoured components to protect the toe of the structures, they would become less susceptible to toe scour failure.

Keywords: Coastal structures, Failure mechanisms, 2004 Indian Ocean tsunami, 2011 Tohoku tsunami, Toe scour, Total disintegration.

SECM/15/051

LIFE EVALUATION OF CRITICAL MEMBERS OF STEEL BRIDGES LOCATED IN DIFFERENT ATMOSPHERES

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Abstract :
Most of the iron and steel bridges in Sri Lanka are more than 100 years old. Since many of them are reaching or exceeding their design lives, the risk of collapsing those bridges have increased. One of the probable damages which bridges experience due to increasing traffic volume as well as environmental degradations such as corrosion is the corrosion fatigue failure. This problem is severe in bridges located in industrial areas and along the coastal line of the country. Corrosion and corrosion fatigue made a huge attention in the recent past due to many failures of bridges all over the world.

This paper presents a study conducted on assessing the corrosion fatigue damage of steel bridges. It proposes a procedure developed using existing fatigue and corrosion models for evaluating the remaining fatigue life. The procedure includes condition surveys, field loading tests, finite element modelling and analysis, developing S-N curves for different atmospheric conditions, use of corrosion rates and assessing cumulative fatigue damage. The paper also presents a case study: a century old iron and steel (mild steel and wrought iron) railway truss bridge damaged by both corrosion and fatigue. Using details of condition survey, load testing, appropriate corrosion data, finite element modelling and a corrosion fatigue assessment procedure, the remaining life of the bridge was evaluated for two atmospheric conditions; (i) corrosive atmosphere and (ii) noncorrosive atmosphere. The results of the evaluation were then compared to show the impact of the atmospheric condition on the fatigue life of the bridge.

Keywords: metal fatigue, corrosion, steel bridge, damage assessment, life evaluation

SECM/15/052

COMMUNITY BASED FLUORIDE REMOVAL FILTER WITHCHICKEN BONE CHAR IN SRI LANKA

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Abstract:
It was reported that most of drinking water sources in Sri Lanka were contaminated with high concentration of fluoride. We established a Chicken Bone Char (CBC) filter on 24th July 2014 at Wilgamuwa village located in the eastern boundary of the central province of Matale district in Sri Lanka. Three pipes with a diameter of 16 cm and a length of 1.5 m were connected in series. Operation capacity of this filter was 150 l/day. Total amount of CBC used for the filter was 23 kg. Water from a selected well in Wilgamuwa village was allowed to pass through the CBC filter and treated water was taken out from the CBC filter. It was obvious that well water at Willgamuwa village had contained higher concentration of fluoride than that of Sri Lankan standard of 1.0 mg/l. Treated water was totally free from fluoride for 142 days equivalent to 21.3 m3. It was expected to operate for 250 days, equivalent to 37.5 m3, without replacing CBC until the fluoride concentration reaches 1.0 mg/l. Chicken bone char can be used to remove fluoride effectively from drinking water in Sri Lanka.

Keywords: well water, Sri Lankan standard, Wilgamuwa

SECM/15/053

INVESTIGATION OF ADMIXTURES EFFECT ON DEGRADATION OF CEMENT PASTE IN SAGD AND CCS WELLS

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Abstract:
In recent years, Steam Assisted Gravity Drainage (SAGD) and Carbon dioxide Capture and Storage (CCS) projects are being developed in oil and gas fields. SAGD is a heavy oil recovery technology to reduce heavy oil viscosity and extract it from underground. CCS is a technology to inject CO_2, emitted from plants, into a couple of 1000m deep ground through well. The deterioration of well in SAGD and CCS projects may cause leakage of deleterious gas.
In this study, mechanical and chemical degradation of hardened cement paste made of Oil Well Cement (OWC) and Geothermal Well Cement (GWC) containing silica flour in the wells was studied experimentally. In order to imitate the underground condition of SAGD, the cement paste was exposed to the drying and moist sealed condition at 200°C. In addition, the cement paste was exposed to supercritical CO_2 to reproduce the condition to inject CO_2 gas in CCS well. The compressive strength tests after exposure to 200°C and thermal analysis to study carbonation after exposure to supercritical CO_2 suggested that the replacement of silica flour to cement is effective to be applied to both SAGD and CCS injection wells.

Keywords: cement paste, fly ash, polymer, supercritical CO_2, 200°C steam.

SECM/15/054

VIRAL HEPERTITIES OUT BREAK IN ELLA, UVA PROVINCE, SRI LANKA

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Abstract:
The study based on Epidemic outbreak of Viral hepatitis in Aluthgama-Kalugalpathana in Ella area. Aluthgama; the small village, five kilometer away from Bandarawela town and it is located in Dova GND in Ella D.S. in Badulla District. The population of Aluthgama village around 750 in 215 number of families. In the month of April 2015 it was reported outbreak of viral hepatitis in Aluthgama area. The investigation study was carried out by National water supply and drainage board with help of health sector of Badulla district. Through the several investigations finally identified the reason for this critical situation as unsafe drinking water supply. Villagers consume water by pipe borne water supply scheme; named kalugalpathana Water supply scheme. The maintains of scheme has been taken over by Ella pradeshiyasabawa since 2013. The small stream flow down from hill-top is based for water project has no proper disinfection process. Study path gave the conclusion as raw water in catchment was contaminated by the people who are deforesting the catchment by living the upper catchment area during that short period. The one of that group was the dieses carrier.

The existing water supply scheme has 137 connections and the component of the scheme content 3 km main, 15m3capacity ferrocement storage tank and distribution system. Proper laying of pipes was not observed. There is no proper disinfection system or good understanding of safe water. Only one lady care taker works in pradeshiyasabawa for maintains and she has no capacity to overcome the water supply problems. Water delivers as intermittence supply and may cause re-contamination within the pipe line. Catchment area content 5 acre which do not sufficient to get enough water quantity. Villagers are very poor and no good hygiene practices. Awareness programs among the villagers done with the help of P.H.I of the area. Apply the Chlorination in proper manner to overcome the faecal contamination of raw water. Water quality testing is carrying out continuously for verify the absence of Bacteriological contamination. Catchment protection program will be introduces.

Keywords: safety, hygiene, quality, satisfactory

SECM/15/055

CONCRETE FILLED STEEL TUBES FOR PERFORMANCE IMPROVEMENT OF STEEL TRUSS BRIDGES

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Abstract:
The use of concrete-filled steel tubes (CFST) in engineering structures has become popular because of their excellent seismic resistance structural properties such as high strength, high ductility and large energy absorption capacity. In CFSTs the surrounding steel tube provides effective confinement to the filled-in concrete and in turn the concrete helps to reduce the potential local buckling of the steel tube resulting improved seismic resistant performance. This study aimed at investigating the benefit of CFST members in railway steel truss bridges susceptible to earthquake loads. Since the end frames of truss bridges are mainly subjected to compressive loads CFST is a good alternative for end raker. The steel weight of the rib can be reduced with CFST and hence the method is economically sound. The seismic behaviour of steel truss bridges with steel and CFST end rakers is discussed based on the results of nonlinear time history analyses. Five truss bridges were designed with different types of end rakers namely existing HEB end raker, square hollow end raker, three square hollow CFST end raker bridges with varying concrete grades. Time history analyses were performed for transverse direction using selected past earthquakes and natural frequencies, maximum vertical and lateral deflections, residual vertical and lateral deflections and member stresses were checked. It was found that the use of CFST in steel truss bridges can be effectively utilized to improve the seismic resisting performance.

Keywords: Concrete-filled steel tube, truss bridges, material nonlinearity, seismic resistance capacity

SECM/15/057

PRELIMINARY INVESTIGATION OF CHANGES IN DAMPING MECHANISM CAUSED BY CORROSION IN REINFORCED CONCRETE BEAMS.

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Abstract:
Corrosion induced damages are one of the major durability issues that reinforced and pre-stressed concrete structures face, during their service life span. Vibration - based test methods have gained great attention in the structural health monitoring field during the last decades as, they are non-destructive and easy of conducting, compared to the other test methods. Dynamic characteristics of undamaged and damaged materials vary from each other and reflected through the modal parameters, like natural frequency, damping ratio and mode shapes, etc. In an RC member, along with the initiation of corrosion process, generation and propagation of corrosion products through the voids in concrete, initiate tensile cracks. Further to that, reinforcement will lose its effective diameter and at a later stage, the bond between reinforcement and concrete is reduced. These internal activities can cause changes in the damping mechanism of that member. Finally, failure will occurs due to loss of bearing capacity of the member. This study is focused on the vibration behaviour of reinforced concrete beam specimens, by performing modal tests under free vibration condition. The accelerated corrosion technique is used to induce artificial corrosion at different degrees. The damping ratio, evaluated by half-power bandwidth method and Eigen system Realization Algorithm was used to investigate changes expected in the damping mechanism.

Keywords: corrosion, non-destructive, vibration, damping mechanism

SECM/15/058

DESIGN AND CONSTRUCTION OF A LARGE SHIPLIFT FACILITY IN INDIA

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Abstract:
To meet the growing shipbuilding needs in Indian subcontinent, L&T Shipbuilding has set-up a modern shipyard facility at Kattupalli near Chennai, India. As part of shipyard infrastructure, a state-of the art Shiplift and Transfer System has been implemented. With facility to handle ships of beam up to 43m and lifting capacity of 21000 MT (expandable to 26000 MT), this is one of the largest shiplifts in the world. To optimize the project cost and develop technology capability, entire planning, design, development and construction of Shiplift system including equipment and control system were handled indigenously. This along with stringent time schedule posed numerous challenges to the project team. Innovative solutions were adopted to overcome challenges and to maintain the project cost within budget. This paper covers the design and construction aspects of Shiplift system with focus on civil works. Challenges faced and solutions adopted are provided. The conclusion of the paper is that world class solutions can be developed and implemented successfully by pooling the available expertise and integrating it with specialist support.

Keywords: shiplift**,** shipyard, drydock, marine structure

SECM/15/060

ASSESSMENT ON DEFECTS OCCURENCE AND REWORK COSTS IN HOUSING CONSTRUCTION SECTOR IN SRI LANKA

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Abstract:
Defects in building construction are considered to be one of the recurring problems in the construction industry. It has adverse effects on project performance, building performance, and client or end-user satisfaction. The lack of focus on defects leads to negative impacts on cost, duration and resources of projects. Defects may generate controversies among parties involved, not only affecting ongoing construction but also during its operation. Rework cost is another effect of defects, absorbs a significant share ranging from 0.5% to 3.7% of total project costs. This research therefore investigates the most frequent defects and rework cost involved in rectifying the defects in residential buildings in Sri Lanka. A questionnaire survey and subsequent interviews to be carried out together with a detailed analysis of documents will be employed to address research focus. 47 housing projects which exposed to defects were studied. Findings of the study indicates that defects such as bulging of columns, beams and slabs, verticality issues of masonry walls, cracks in plastering and painting, defects in doors and windows are more likely to occur in residential buildings in Sri Lanka. The mean total rework cost as a percentage of the cumulative work done value was found to be 0.92%. For a mean total rework cost of 0.92%, the likelihood that a project exceeds is 52%. Finally, the study proposes strategies such as proper documentation, proper coordination of works and uplift the attitude towards reporting the defects of lower level staff would help practitioners to minimise the defects in building construction in Sri Lanka.

Keywords: defects, housing construction, rework costs, Sri Lanka

SECM/15/061

DEVELOPMENT AND PERFORMANCE EVALUATION OF THE LEACHATE TREATMENT SYSTEM AT GOHAGODA MUNICIPAL SOLID WASTE DISPOSAL SITE

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Abstract:
A private company with technical support of University of Peradeniya has undertaken the task of rehabilitating the Gohagoda dumpsite. Not all of the leachate collection system (*LTS*) is completed yet and runoff water too gets mixed with the leachate on one side of the dumpsite. The *LTS* consisting of leachate collection tanks, a leachate treatment bioreactor(*LTB*) followed by an algae pond(*AP*), a floating wetland(*FW*), two sub-surface constructed wetlands(*SCWs*), two charcoal filter-beds(*CFBs*). LTS_{outlet} is being discharged into a natural stream *(NS*). In this research, the existing *LTS* was improved and the performances were evaluated. To determine the surface water quality of surrounding area and performance of the *LTS*, samples were obtained from 13 pre-defined points on weekly basis for two months, analysed for 14 quality parameters.

Average pH, dissolved oxygen (DO), chemical oxygen demand (COD) and biochemical oxygen demand (BOD) of inlet leachate to the *LTS* were 7.74±0.35, 0.46±0.5mg/L, 24,552±2,612mg/L and 4,125±965mg/L respectively. LTS_{outlet} of pH (7.16±0.23) was within the Central Environmental Authority water quality discharge standards. Average salinity, EC, DO, TDS, TSS, TS, VS, VSS, BOD, COD, PO_4^{-3}, NO_3^- and $NH_4^+$of LTS_{outlet} were 0.84±0.25%0, 1.71±0.52mS, 0.63±0.6mg/L, 852±261mg/L, 1,058±199mg/L, 1,303±772mg/L, 406±220mg/L, 609±111mg/L, 217±177mg/L, 780±1,049mg/L, 2.33±3.29mg/L, 0.97±0.27mg/L, 4.38±1.59mg/L respectively. Average pH, TDS, BOD, PO_4^{-3} and NO_3^- and NH_4^+ of NS_{outlet} were 7.69±0.39, 1,457±930mg/L, 1,382±784mg/L, 5.04±6.36mg/L, 1.58±1.26mg/L, 4.3±2.02mg/L respectively. The average removal efficiency of BOD was 95%.

The lower values of the indicative parameters were when the *LTS* was stabilizing and attaining the required standards even without high growth in *SCWs*, until heavy rainfall occurred. Therefore, it is essential to install sub-surface leachate interceptor drains and those connected to the leachate treatment system. It will require a proper dumpsite cover system to reduce infiltration and thus promote runoff. It is imperative to monitor and evaluate frequently the system and improve it with an aerated biological indicator pond.

Keywords: clay-polythene-clay biofilter liner, dumpsite, rehabilitation, leachate treatment

SECM/15/063

DAMPING PROPERTIES OF EXISTING SINGLE-SPAN PRESTRESSED CONCRETE GIRDER BRIDGES WITH DIFFERENT SERVICE PERIODS

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Abstract:
Invisible damages in bridges, such as corrosion of rebar, may not be detected by periodic visual inspection that is the principal method in bridge maintenance. A possible non-destructive technique which has been investigated to assist visual inspection is vibration-based structural health monitoring. The modal properties of bridges, such as the natural frequencies, mode shapes and modal damping ratios, are expected to change due to damages and/or deteriorations. In the present study, damping properties of existing PC girder bridges were identified so as to investigate the possibility of the modal damping ratios as an indicator of damage detection. Vibration measurements were made at ten single-span PC bridges with similar dimensions under normal service conditions by using wireless and wired sensor systems. Eigensystem realization algorithm (ERA) with an improved screening process was applied to extracted free vibration records. Modal properties up to the fourth vibration modes were identified for many bridges. For the third vibration mode that was identified stably in most bridges, there was a trend that the modal damping ratio of old bridges was greater than other newer bridges. Although this result does not necessarily indicate the relationship between the damage and damping property, it may support the possibility of damping in the evaluation of structural state.

Keywords: damping properties, eigensystem realization algorithm, single-span prestressed concrete girder bridge

SECM/15/067

EXPERIENCE FROM IMPLEMENTING THE EHELIYAGODA WATER SUPPLY SCHEME WATER SAFETY PLAN

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Abstract:
Eheliyagoda Water Supply Scheme (WSS) is situated within the Eheliyagoda Divisional Secretariat Division of Rathnapura District. The raw water source is BisoDola stream which is a tributary of River Kalu Ganga. Catchment area of the source upstream to the intake point is 3.4 km2 and mainly consist of Rubber Plantation belonging to Eheliyagoda Estate (75%) and small holder Tea plantations with home gardens (25%). Main pollution sources to the stream are waste water from latex processing factory of Eheliyagoda Estate, soil erosion during rains, accumulated agro chemicals and fertilizer, water from human usage (E.g.washing, bathing) etc. Introducing a Catchment Management Plan (CMP) to minimize the above pollution is the main challenge of the Eheliyagoda Waster Safety Plan (WSP). To address the above issues, the CMP should be implemented through a participatory approach with all stakeholders. Major components of the proposed CMP are introducing a model analog forest to the upper catchment, introducing organic farming to rubber, tea and home gardening systems, upgrading the waste water treatment system of the rubber factoryby introducing a constructed wet land; strengthening the existing by-pass effluent line; improving the sewage disposal of the dwellers who are living adjacent to the stream and demarcation and upgrading the stream reservation. At the initial stage,four model farms will be introduced, one for organic rubber, onefor organic tea and two organic home gardens.The home gardens will mainly focus on production of home food requirements and excess production could be used for income generation. They are mainly focused for the women who would productively use their efforts. Markets are already available for the organic rubber, tea and food products with high selling prices. The questionnaire survey from 100 dwellers in the catchment area revealed that 75% are agreeable to this proposal. CMP targets to increase water holding capacity of the catchment area through organic farming in living areas while upgrading the living standardsinstead of replacing the dwellers. It will be an ideal achievement for a successful implementation of the WSP. As a result of increasing water holding capacity of soil through organic farming and analog forestry, quality and quantity of the stream flow will increase,which is one the main objectives of the WSP. Water treatment plant improvement and distribution system improvement using GIS technology have also been initiated through the WSP.

SECM/15/070

NUMERICAL ANALYSIS OF THE BACKFILLING SEQUENCE EFFECT ON GRAVITY RETAINING WALL BEHAVIOR

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Abstract:
Gravity retaining walls derive their capacity to resist lateral movement through the dead weight of the wall. The design methodologies proposed by standards do not take into account the construction sequences that simulate the process by which the soil and retaining wall are brought together. However, in reality, at least during the backfilling process, the retaining wall undergoes many displacements that are not so far considered in the design. In this investigation, effect of construction sequences in the gravity retaining walls with different shapes is investigated with the help of finite element method. Two different construction sequences, namely the backfilling after wall construction and the backfilling parallel to wall construction, are compared for different wall shape models. Lateral displacement of the bottom and the top of the wall is plotted for each model and construction sequence with construction stages. Bearing pressure distribution, lateral earth pressure and failure wedge angle are summarized and compared with design values. Each wall showed different behaviours for each of the construction sequences. Back filling after wall construction minimizes the sliding failure and bearing pressure. Overturning failure could be reduced by backfilling parallel to wall construction. However, it was observed that, comparatively, backfilling after wall construction is effective than backfilling parallel to wall construction, suggesting that proper selection of construction method also may reduce negative effects on the wall stability.

Keywords: gravity retaining wall, construction sequence, numerical modelling, backfilling, lateral displacement

SECM/15/071

FACILITIES MANAGEMENT APPROACHES FOR SUSTAINABILITY

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Abstract:
In its most general sense sustainability is the capacity to endure. Sustainability has emerged as a result of significant concerns about the unintended social, environmental, and economic consequences of rapid population growth, economic growth and consumption of natural resources. Sustainability depends on three basic pillars; environmental, social and economical sustainability. In order to be sustainable, these three areas of sustainability must be achieved throughout the life cycle of a facility. The facility manager is in a unique position to view the entire process and is often the leader of the only group that has influence over the entire life cycle of a facility. Therefore, the facility manager often becomes the proponent of sustainable and green practices. Armed with the proper approaches, the Facility Manager can create long-lasting value to the organisation by developing, implementing and maintaining sustainable facility practices. Therefore, this study attempts to pinpoint the Facilities Management approaches to achieve and maintain environmental, social and economical sustainability.

A comprehensive literature review was carried out on a broader perspective with the purpose of getting familiarize with the research phenomena. Interview guidelines were developed based on the findings of the literature review. In order to validate and further the literature findings five expert interviews were carried out with experienced industry practitioners.

Research findings revealed that in Sri Lankan context, a Facility Manager's involvement for maintaining sustainability is most crucial in the operational phase of a facility. FM should have a clear view of environmental, social and economical aspects of sustainability. He / She should equally value the three pillars and a balanced approach needs to be taken in order to maintain a facility that is sustainable.

Keywords: facilities management, sustainability, facilities

SECM/15/074

BASE COURSE GEOCELL REINFORCEMENT EVALUATION BY COMPARING 3-D FEM AND LABORATORY EVALUATION

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Abstract:
The shortage of high-grade base material and emphasis on using recycling base material has led to use of geocells reinforced bases in the past decade. The geocells provide reinforcement by confining base material and have been used for increasing bearing capacity of supporting soil, reducing settlements, using inferior quality material, reducing thickness of base layers, etc. It can be an economical option in rehabilitation of pavements and construction of low volume roads. Various studies have been conducted to evaluate the behaviour of geocell reinforced layers using expensive and time intensive laboratory tests. The working principle of geocell reinforced layers using various pavement materials, loading types, geocell types etc., can be comprehended quickly and economically using Finite Element Modelling (FEM). In this study, various significant FEM model parameters like constitutive material models and contact models were examined. The results were compared with the laboratory test results and specific contact and constitutive material models that predict behaviour similar to the laboratory results were recommended.

Keywords: geocell, finite element modelling (fem), contact models, constitutive models

SECM/15/075

DEVELOPMENT AND IMPLEMENTATION OF WATER SAFETY PLAN IN KONDAWATUWANA WATER SUPPLY SCHEME

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Abstract:
Water quality testing is an important component of water supply system management, but it is not adequate to ensure water safety due to late results, spot check only, limited laboratory capacity and expensive testing. For these reasons, the World Health Organization (WHO) Guidelines for Drinking-water Quality and the International Water Association (IWA) Bonn Charter recommend pro-active efforts to reduce risks and prevent contamination before water reaches the consumer. This can be achieved by shifting emphasis of drinking-water quality management to a holistic risk-based approach that covers the catchment-to-consumer. Such an approach is called Water Safety Plans (WSPs). WSPs are promoted by the WHO as the most effective means of securing drinking water safety. To date most experience with WSPs has been within utility supplies, primarily in developed countries. Currently, NWSDB is motivating to develop and implement the WSP approach in water supply system in Sri Lanka.

This objective of the study is to develop and implement a WSP for Kondawattuwana water supply scheme in order to ensure safe drinking water as water safety plan is always location specific. Literature review was done to understand framework of the WSP and to study water quality of the Kondawattuwana Water supply scheme. Presentations were arranged to NWSDB staff and identified stakeholders to understand the important of the WSP and benefits from implementing WSP for Kondawattuwana water supply scheme. WSP core teams were set up and catchment survey was carried out by the WSP team to identify all hazards and hazardous events that can affect the safety of water in the catchment.

Workshop discussions were held for WSP teams and O&M staffs including treatment plant operators to assess the risks; to identify the existing control measures from catchment to consumers. The risk were assessed using a semi-quantity approach, the re-assessed risked were prioritized with the standard risk matrix; verification of control system, management procedure, supporting program and upgrade plans were discussed from catchment to consumers. Water Safety Index is introduced as a bench marking management tool in order to monitor the progress of implementation of WSP. The WSPs are well accepted by stakeholders and NWSDB staff. The priorities were given to rehabilitate the systems based on the above risk identifications.

Keywords: water safety plan, water treatment, water quality monitoring

SECM/15/076

HIGH PERFORMANCE CONCRETE INCORPORATING FLY ASH, NANO-SILICA (NANO-SIO2) AND MICRO-SILICA (MICRO-SIO2)

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Abstract:
High performance concrete (HPC) exceeds the properties and constructability of normal concrete. Normal and special materials such as fly ash, micro silica and nano silica are used to make these specially designed concretes that must meet a combination of performance requirements. There are many good reasons to view fly ash, micro silica and nano silica as blended materials in concrete. In many cases, concrete made with fly ash, micro silica and nano silica performs better than concrete made without them.

In this paper, an effort was made to evaluate the effect of nano-silica (nano-SiO2), micro-silica (micro-SiO2) and fly ash in improving the properties concrete. Firstly, compressive strength of concrete with different percentage of nano-silica (nano-SiO2), micro-silica (micro-SiO2) and fly ash was studied. Secondly, compressive strength of concrete with Ordinary Portland cement (OPC) and Portland fly ash cement (PPC) was studied. Thirdly, compressive strength of concrete with combination of fly ash and micro silica (micro-SiO2) was studied.

Keywords: fly ash, micro SiO2, nano SiO2, high performance concrete

SECM/15/080

VERTICAL UPLIFT CAPACITY OF A GROUP OF EQUALLY SPACED HELICAL SCREW ANCHORS IN SAND

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Abstract:
This paper presents the experimental investigations on the behaviour of a group of single, double and triple helical screw anchors embedded vertically at the same level in sand. The tests were carried out on one, two, three and four numbers of anchors in sand for different depths of embedment keeping shallow and deep mode of behaviour in mind. The testing program included 48 tests conducted on three model anchors installed in sand whose density kept constant throughout the tests. It was observed that the ultimate pullout load varied significantly with the installation depth of the anchor and the number of anchors. The apparent coefficient of friction (f*) between anchor and soil was also calculated based on the test results. It was found that the apparent coefficient of friction varies between 1.02 and 4.76 for 1, 2, 3 and 4 numbers of single, double and triple helical screw anchors. Plate load tests conducted on model soil showed that the value of _ increases from 35o for virgin soil to 48o for soil with four double screw helical anchors. The graphs of ultimate pullout capacity of a group of two, three and four no. of anchors with respect to one anchor were plotted and design equations have been proposed correlating them. Based on these findings, it has been concluded that the load-displacement relationships for all groups can be reduced to a common curve. A 3-D finite element model, PLAXIS, was used to confirm the results obtained from laboratory tests and the agreement is excellent.

Keywords: apparent coefficient of friction, helical screw anchor, installation depth, plate load test

SECM/15/081

ANALYSIS OF FACTORS CONTRIBUTING CIVIL ENGINEERING PROJECT DELAYS IN SRI LANKA

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Abstract:
A construction project is commonly acknowledged as a successful project when the aim of the project is achieved in terms of predetermined objectives of completing the project on time, within budget and to the required quality standard. Delay in the completion of a construction project can be a major problem for contractors, consultants as well as for clients. These delays lead to costly disputes and adverse relationships amongst project participants. Projects can be delayed due to large number of reasons. The reasons are related to various types of uncertainties associated with activities during the construction process or during the planning and design stages. Therefore a comprehensive survey was carried out to identify the critical factors that cause the delays in Sri Lankan construction projects. From in-depth literature studies, 52 causes of delay were identified. Questionnaire survey was carried out among 107 selected construction projects in Sri Lanka. The findings show that the delay in Sri Lankan construction projects is mostly originated by labour, followed by contractor and client, while external related causes are less important. This paper also explores and provides some recommendations to reduce the impact of delays on civil engineering projects in Sri Lanka.

Keywords: construction delays, delay causes, Sri Lankan project delays, delay factors, Sri Lankan construction industries

SECM/15/082

THE CHALLENGES AND OBSTACLES OF POST-DISASTER ROAD INFRASTRUCTURE RECONSTRUCTION IN THE PRE-CONSTRUCTION PHASE

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Abstracts:
The reconstruction of road infrastructure in the post-disaster context requires different approach when compared with road projects in the normal development context. Disaster recovery projects are seen as having their own unique identity, particularly due to stakeholder issues, resource challenges, capability issues, and even long-term reliability concerns. This paper invites a discussion regarding the challenges and obstacles identified in the reconstruction of road infrastructure in a post-disaster reconstruction setting, and focus the discussion on the pre-construction phase.

The challenges and obstacles presented in this paper are based on the literature and the empirical evidence collected from the research in three case study districts in Aceh, Indonesia. Twenty eight face to face semi-structured interviews were conducted with stakeholders of road infrastructure at the local, provincial and national level, and represented by respondents from the public works, planning agency, disaster management agency, consultant, contractors, and donor agencies. The findings were triangulated with the literature and consulted with five experts in the road infrastructure and disaster reconstruction area.

The identified challenges and obstacles are divided into three groups of discussion; planning and programming, road design, and procurement. Whilst some of these challenges are not unique to post-disaster context, the scale of the risks had been undermined.

This paper identifies the challenges and obstacles of a road project in the post-disaster setting from the pre-construction perspective. Identification of these challenges and obstacles may help improve the implementation of post-disaster road infrastructure reconstruction projects in future recovery projects, particularly in the developing world.

Keywords: road infrastructure, post-disaster reconstruction, project management

SECM/15/083

DERIVING DAMAGE INDICES FOR CONCRETE GIRDER BRIDGES SUBJECTED TO FLOOD LOADING

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Abstract:
It is noted that the intensity and frequency of disasters have increased over the past few decades and the damage to infrastructure after a natural hazard has consequently increased. The recent flood events in Queensland, Australia had an adverse effect on the country's social and economic growth. Due to climate change impacts, it is reported that the frequency and intensity of flood events have increased noticeably in recent years. Failure of transport infrastructure after a flood event significantly affects the community, road authorities and wider stakeholders. Bridge structures are often vulnerable to flood events due to their proximity to water ways and the resultant direct impact of flood on structures. In identifying strengthening needs for vulnerable bridge structures, a damage, flood intensity relationship is required.

The paper has reviewed different bridge design codes used over several years in Australia for designing the bridges and the method of design for flood loading is identified. Various failure mechanisms of bridges due to flood events have been investigated through analysis of case studies and the most common failure mechanisms of the bridges in Queensland as the result of the 2011 and 2013 flood events have been identified. A case study bridge has been modelled using the general purpose finite element software, ANSYS. The damage to bridges due to impact of floating items under different flood scenarios have been investigated. Damage curves have been generated for the case study bridge under different flood intensities.

Key Words: bridge, flood, ansys, damage curves

SECM/15/085

GEOPOLYMER AS WELL CEMENT AND ITS MECHANICAL BEHAVIOUR WITH CURING TEMPERATURE

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Abstract:
Carbon capture and storage (CCS) technique is found as a best solution to reduce the emission of CO_2 to the atmosphere. In this technique, the CO_2 emitted from large industries is captured, and pressurized, and finally injected into deep underground reservoirs. In a geological sequestration project, integrity of injection well play an important role. It means the well cement is a key factor that affects the well integrity. In typical injection wells, Ordinary Portland cement (OPC) based cement is used as well cement and it has been found that it undergoes degradation in CO_2 rich environment. Geopolymer can be a good alternative to existing OPC based well cement as it has been found that geopolymer possess high strength and durability compared to OPC. Geopolymer is a binder produced through the process called geopolymerization of alumino- silicate materials and alkaline activators. In the sequestration wells, well cement is exposed to different curing temperatures with a geothermal gradient of 30°C/km. Therefore, it is important to study the mechanical behaviour of well cement with curing temperatures expected deep under the ground. Therefore, this research aims to study geopolymer as well cement and its mechanical behaviour at different curing temperatures (25, 40, 50, 60, 70, 80 °C). In addition, effect of ageing on the mechanical behaviour was also studied. The OPC samples were tested for the comparison of results with geopolymer. The results showed that the optimal curing temperature for higher strength of geopolymer and OPC are 60 °C and 50 °C respectively. Geopolymer possess highest strength at elevated temperatures whereas OPC possess higher strength at ambient temperatures. Moreover, at elevated temperature curing, geopolymer develops ultimate strength within short curing period and it does not gain significant strength with further ageing.

Keywords: CO_2 sequestration, geopolymer, greenhouse gases, well cement

SECM/15/088

STUDY ON THE IMPACT OF ACCIDENTS ON CONSTRUCTION PROJECTS

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Abstract:
As the construction industry is carried out in hazardous environments, it experiences accidents in different levels of severity, some causing minor and major injuries with even some resulting in fatality. In addition to the human cost involved, it also causes bad publicity to the profession. Worldwide, authorities have tightened up safety standards, which have enhanced the performance in construction sites. However, accidents are still happening and there is a need for further research on this important subject.

From construction organization's point of view, accidents are unexpected events and unplanned costs. Some accidents may change the organizational goals or it could even make the company uncompetitive in the industry. A good understanding of accident forecasting is vital in construction project management. This research explores four questions that arise in accidents in construction sites. Namely, (1) What are the impacts of accidents on construction work? (2) What are the uncertain contributory factors in these accidents? (3) How are human and financial aspects linked to accidents? (4) What are the possible project performance enhancements under uncertainty factors of the accident?

The objectives of this research paper are (i) to investigate construction site accidents to identify the critical causes and effects; and (ii) establish relationship of accidents with additional project cost, additional time, project scope, company reputation, and impact on national safety indexes. While human errors were identified as the main cause for construction accidents, negligence or mistakes can happen due to the uncertain circumstances. Hence, unavoidable accidents have to be expected in the construction industry. The commitment of all humans involved, from the project manager to the labourer towards good practices would enhance the safety performance in construction sites.

Keywords: accidents, accident forecast

SECM/15/089

FATIGUE CAPACITY OF COLD-FORMED STEEL ROOF BATTENS UNDER CYCLIC WIND UPLIFT LOADS

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Abstract:
Steel roofs made of thin cold-formed steel roof claddings and battens are widely used in low-rise residential and industrial buildings all around the world. However, they suffer from premature localised pull-through failures in the batten to rafter connections during high wind events. A recent study proposed a suitable design equation for the pull-through failures of thin steel roof battens. However, it was limited to static wind uplift loading. In contrast, most cyclone/storm events produce cyclic wind uplift forces on roofs for a significantly long period, thus causing premature fatigue pull-through failures at lower loads. Therefore, a series of constant amplitude cyclic load tests was conducted on small and full scale roof panels made of a commonly used industrial roof batten to develop their S-N curves. A series of multi-level cyclic tests, including the recently introduced low-high-low (LHL) fatigue loading test, was also undertaken to simulate a design cyclone. Using the S-N curves, the static pull-through design capacity equation was modified to include the effects of fatigue. Applicability of Miner's rule was evaluated in order to predict the fatigue damage caused by multi-level cyclic tests such as the LHL test, and suitable modifications were made. The combined use of the modified Miner's law and the S-N curve of roof battens will allow a conservative estimation of the fatigue design capacity of roof battens without conducting the LHL tests simulating a design cyclone. This paper presents the details of this study, and the results.

Keywords: cold-formed steel structures, steel roofing systems, thin steel roof battens, wind action, pull-through failures, fatigue, miner's rule

SECM/15/090

DEVELOPMENT OF A CAPPING MATERIAL FOR AN ENGINEERED LANDFILL IN WET ZONE OF SRI LANKA

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Abstract:
Capillary Barriers (CB) which consist of coarse sand overlain by a low permeable fine soil are low cost alternatives used in capping system for controlling the infiltration in a Landfill. In wet region, the durability of capping layer is questionable as due to high precipitation, capillary effect can reduce making the layer highly permeable. A potential solution is to alter the soil grains by mixing with a Hydrophobic Agent (HA) such as Oleic Acid (OA), so that the water repellent characteristics are introduced into the sand layer.

In this study, the hydrophobicity (water repellency) of CBs containing coarse sand mixed with OA was investigated. Hydrophobicity was evaluated by measuring the time taken for a water droplet to penetrate the surface of a compacted sand sample which is identified as the Water Drop Penetration Time (WDPT). Initially, dry coarse sand particles were hydrophobized by mixing-in coating method with different OA contents. In addition, the effect of moisture content of coarse sand particles on its hydrophobicity was also studied. The results show that WDPT for dry samples increased sharply with increasing HA content and reached a peak value of 4080 s at $3gkg^{-1}$ of sand and thereafter decreased. Irrespective of the OA content, an increase in moisture content decreased the water repellency. However, this decrease is less significant for the optimum value of OA content of $3gkg^{-1}$ within the range of moisture content tested. The impact of the slope angle on the water repellancy was also investigated by increasing the slope upto 1V:3H. Results showed a decrease in water repellency when the slope angle was increased. It was observed that water drop was spreading due to the effect of weight acting along the slope and as a result the WDPT time decreased due to less surface tension.

Keywords: capillary barrier, capping material, water repellence

SECM/15/093

GENERAL CHARACTERISTICS OF HOSPITAL WASTEWATER FROM THREE DIFFERENT HOSPITALS IN SRI LANKA

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Abstract:
The hospital wastewater in Sri Lanka is a particular concern possibly due to the hazardous and toxic nature and its direct discharge into water bodies. Hence, this study focuses the characterization of wastewater generated from hospitals in Sri Lanka to assess the spatial and temporal variations. Wastewater samples were collected monthly from three different hospitals over a period of 3 months and they were tested for quality parameters: pH, temperature, electrical conductivity, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), volatile solids (VS), volatile suspended solids (VSS), biological oxygen demand (BOD_5), chemical oxygen demand (COD), nitrate-N, phosphates and heavy metals. The results revealed that hospital wastewater exceeds the allowable limits of Sri Lankan wastewater discharge standards for many of the parameters. The maximum recorded values for TS, TDS, TSS, VS and VSS were 2658, 560, 314, 126 and 235 mg L^{-1}, respectively. The demonstrated values for BOD_5, COD were falling into a large range, 6-1950 and 130-1183 mg L^{-1}. Nitrate-N and phosphate concentration varied and upper limit were reported as 3696 and 103.74 mg L^{-1}. Apparently, maximum concentration of Cr(VI), Mn and Pb were reported as 0.23, 0.52 and 0.90 mg L^{-1}. Further studies are undertaken to analyze volatile organic compounds (VOCs) and pharmaceuticals.

Keywords: BOD_5, COD, Heavy metals, Pollutants, Water quality

SECM/15/094

HEAVY METALS IN ATMOSPHERIC DEPOSITION IN KANDY CITY; IMPLICATIONS FOR URBAN WATER RESOURCES

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Abstract:
Atmospheric deposition is a serious issue in the context of biogeochemical cycling of heavy metals (HMs) and the resulting impacts on urban water resources. In this study, dry deposition (DD) and bulk deposition (BD) samples were collected from four sites located in heavy traffic areas in Kandy, Sri Lanka. Wet deposition (WD) was determined from the difference between DD and BD. Samples were analyzed for Al, Cr, Mn, Fe, Ni, Cu, Zn, Cd and Pb using inductively coupled plasma-mass spectrometry. Relatively high concentrations of Fe, Al and Zn were found in both DD and WD samples collected. In BD, percentage dissolved fraction of Ni, Cr, Cu, Cd, Al and Pb was 94, 86, 81, 78, 61, 46% respectively. Presence of high dissolved fraction of highly toxic HMs such as Cr and Pb can result in significant ecosystem health impacts due to their ready bioavailability. The presence of metals such as Al, Fe, Zn, Pb, Cr and Cd in WD was consistently more significant compared to DD. The presence of high concentrations of mobile forms of metals in WD will contribute to the pollution of urban stormwater, resulting in the degradation of urban receiving water environments and associated ecosystems.

Keywords: atmospheric deposition, heavy metals, storm water quality, urban water pollution

SECM/15/095

POTENTIAL OF DIFFERENT BIOCHARS FOR GLYPHOSATE REMOVAL IN WATER; IMPLICATIONS FOR WATER SAFETY

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Abstract:
We investigated the potential of two different types of biochars (BCs), a waste by product from a Dendro bioenergy industry (DBC) and a steam activated rice husk derived biochar (SRBC) to remove glyphosate from aqueous media. Equilibrium isotherms and kinetics experiments were conducted to study the adsorption behaviour and postulate potential mechanisms. Glyphosate adsorption on both BCs was strongly pH dependent, exhibiting maximum on DBC and SRBC at 5-6 and 2-4 pH, respectively. Isotherm data obtained for DBC adsorption was best fitted to Freundlich and Temkin models indicating a multilayer adsorption, whereas glyphosate adsorption on SRBC was well described by Freundlich and Langmuir models suggesting both physisorption and chemisorption mechanisms for the adsorption process. The Langmuir maximum adsorption capacity of DBC and SRBC was 44.00 and 123.03 mg/g, respectively. The kinetics of glyphosate adsorption on DBC were best described by pseudo-second order mode indicating that the rate limiting step can possibly be a chemical adsorption, while pseudo-first order model described kinetics of glyphosate adsorption on SRBC indicating physisorption interactions for glyphosate adsorption. Pore diffusion, π^*-π electron donor-acceptor interactions and H-bonding were postulated to be involved in physisorption, whereas electrophilic interactions led to chemisorption type of adsorption for both DBC and SRBC. Overall, both DBC and SRBC could be a promising remedy of glyphosate removal from aqueous solution.

Keywords: pesticides, physisorption, chemisorption, kinetics, adsorption capacity

SECM/15/096

DETECTION OF BENZENE IN LANDFILL LEACHATE FROM GOHAGODA DUMPSITE AND ITS REMOVAL USING MUNICIPAL SOLID WASTE DERIVED BIOCHAR

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Abstract:
Numerous landfill associated volatile organic compounds (VOCs) are emerging concern due to their potential risk of health. Benzene is one of the most common VOCs in landfill leachate. Biochar has bulged as a universal sorbent for the removal of contaminants from water and soil. Hence, this study examines the potential of biochar derived from municipal solid waste (MSW-BC) on adsorption of benzene so that MSW can be recycled to treat its own pollutants. Landfill leachate was collected from five sampling points at Gohagoda MSW dumpsite and analyzed for benzene. In order to evaluate the potential of MSW-BC for removal of benzene from water, the equilibrium adsorption was procured by using headspace GCMS. The effects of pH, contact time and sorbent (1-10 g/L), sorbate (30-300 µg/L) concentration were investigated using a batch sorption technique. Benzene was detected in landfill leachate, approximately 20 µg/L. The batch experiments indicated that benzene adsorption was dependent solution pH and percentage removal became higher above pH 7 and highest adsorption 42.7 µg/g was observed within 24 hours at pH 9. Maximum saturated sorption capacity of MSW-BC for benzene was 87.0 µg/g. Preliminary experiment data suggest a potential of MSW-BC to be utilized as a material for VOC remediation from MSW dumpsites.

Keywords: adsorption**,** benzene, landfill leachate, msw biochar

SECM/15/099

SHEAR STRENGTH CHARACTERISTICS OF DIFFERENT GRADATIONS OF BALLAST USING PARALLEL GRADATION TECHNIQUE

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Abstract:
Ballasted rail tracks are most commonly used rail track structure and to be designed to provide a stable, safe and economical foundation. Main components of ballasted rail track structure could be subdivided as track superstructure and track substructure. The loading from the train will be distributed from the superstructure to substructure. The main structural component of substructure is considered as track ballast which is generally crushed hard stones. Railway authorities specify gradation specifications for selection of ballast for rail tracks. Sri Lanka railways also specified a gradation limits in the selection of ballast for rail tracks. Current standard is closely resembled to the Indian rail track ballast specifications. Commonly, the ballast used in Sri Lanka is crushed gneiss rocks which are in abundance. It is well understood that granular materials derive its strength by resistance to shearing. However, there is no examination conducted to evaluate the performance of rail track ballast used in Sri Lanka considering the shear behaviour. The objective of this preliminary study is to investigate the shear strength characteristics of ballast gradation used in Sri Lanka and compare with selected other ballast gradation specifications. Parallel gradation technique was used to model the sample as it is difficult to handle large size ballast in the conventional direct shear box. Direct shear tests were conducted under three normal pressures of 15 kPa, 45 kPa and 90 kPa on different ballast gradations including current Sri Lankan specification. The results showed that the Current Sri Lankan ballast gradation specification which is the same as Indian standard gradation has the highest shear strength compared to other ballast gradations tested.

Keywords: ballast, ballast gradations, shear strength, parallel gradation technique

SECM/15/100

STABILITY OF AN OPEN DUMPSITE WITH AGEING

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Abstract:
Open dumping is the most commonly used method adopted in Sri Lanka as solid waste management. However, slope failures of open dump sites lead to environmental pollution as most of the open dumps are located near water bodies. Therefore, analysing the stability of open dumps is important in implementing mitigatory measures where required. Abandoned Udapalatha open dump site which is located near Gampola, Sri Lanka was considered as a case study to analyse the stability of its slopes consisting of old and new waste representing different degrees of decomposition. Shear strength parameters of the waste samples of the old and new waste sites were determined using box samples at different depths with particle size less than 9.5 mm. Specific gravity test, Oedometer test and Standard Proctor compaction test were performed to obtain Gs, primary and secondary consolidation parameters, maximum dry density and the optimum moisture content. In addition, direct shear test was carried out to determine the shear strength parameters of the fill. Slope stability analysis was carried out using Slope/W and Plaxis-2D software considering Mohr Coulomb and soft soil creep models respectively for waste material. Consideration of primary and secondary consolidation settlement within the landfill in the Plaxis-2D analysis resulted in an increase in the Factor of safety (FOS). Therefore, FOS values obtained from the slope stability analysis of the old site, was higher than that in the new waste site.

Keywords: ageing, secondary consolidation, shear strength, slope stability

SECM/15/101

BEHAVIOUR OF DIFFERENT BRACING SYSTEMS IN HIGH RISE 3-D BENCHMARK BUILDING UNDER SEISMIC LOADINGS

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Abstract:
This paper presents the seismic behaviour of different bracing systems in high rise 20 storey 3-D benchmark steel building. A nonlinear static pushover analysis was carried out to on different braced 20 storey high rise 3-D benchmark steel building to capture the seismic response. In this study, five structural configurations were used: moment resisting frames (MRF), chevron braced frames (CBF), V-braced frames (VBF), X-braced frames (XBF), and zipper braced frames (ZBF). The primary goal of this study is to investigate the seismic behaviour of different bracing systems in a benchmark building under the different lateral load patterns. It is seen that the type of bracing system significantly influences the performance of high rise buildings. The seismic performance of the 20 storey benchmark building is measured in terms of the fundamental time period, capacity curve, storey displacement, and inter-storey drift ratio. It can be concluded from the study that the seismic resistance can be increased by use of the CBF, VBF, and ZBF than XBF and MRF.

Keywords: seismic behaviour, high rise 3-d benchmark steel building, bracing systems, nonlinear pushover analysis, capacity curve

SECM/15/103

THIRD REVOLUTION DIGITAL TECHNOLOGY IN DISASTER EARLY WARNING

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Abstract:
Networking societies with electronic based technologies can change social morphology, where key social structures and activities are organized around electronically processed information networks.

The application of information and communications technologies (ICT) has been shown to have a positive impact across the emergency or disaster lifecycle. For example, utility of mobile, internet and social network technology, commercial and amateur radio networks, television and video networks and open access technologies for processing data and distributing information can be highlighted. Early warning is the key function during an emergency. Early warning system is an interrelated set of hazard warning, risk assessment, communication and preparedness activities that enable individuals, communities, businesses and others to take timely action to reduce their risks. Third revolution digital technology with semantic features such as standard protocols can facilitate standard data exchange therefore proactive decision making. As a result, people belong to any given hierarchy can access the information simultaneously and make decisions on their own challenging the traditional power relations. Within this context, this paper attempts to explore the use of third revolution digital technology for improving early warning.

Keywords: disaster, digital technology, early warning, tsunami

SECM/15/105

CATCHMENT PROTECTION OF GIN GANGA (RIVER) AS PART OF WATER SAFETY PLAN (WSP) IN GREATER GALLE WATER SUPPLY SCHEME (GGWSS)

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Abstract:
Gin Ganga (River) is the main raw water source to Greater Galle water Supply Scheme (GGWSS). Managing drinking water quality from catchment to consumer is the main objective of the Water Safety Plan (WSP) of GGWSS. There are three Water Treatment Plants (WTP) purifying and delivering 80,000m³ of treated water per day to approximately 450,000 people through 15 distributions centers. The Gin River has a total length of 113km and a catchment area of about 932 km² Catchment of the Gin River includes Galle, Matara, Ratnapura and Kalutara administrative districts. The Gin River originates from the Gongala mountains in Deniyaya and flows to the Indian Ocean at Gintota in Galle. Gin River annually discharges about 1268 million m³ of water to the sea. Rainfall pattern in the catchment is bimodal, falling between May and September and again between November and February. Rapid changing of land use pattern and high rate of application of agrochemicals and fertilizers has significantly affected the raw water quality. A quantitative and continuous assessment of water quality along Gin River is necessary to identify the trends and to develop sustainable remedial actions. Content of heavy metals in raw water is also an important parameter to be tested due to lack of previous data. The WSP Team is already established and the Greater Galle WSS WSP has been completed. The External Stakeholder Team consists of relevant stakeholders; the Galle District Secretary, relevant Divisional Secretaries, Health Authorities, Irrigation Officials, Agriculture Officials, Central Environmental Authority etc. The initiatives and the encouragement of the External Stakeholder Team to implement the catchment protection program for Gin River is commendable as the group has already carried out a Sanitary Survey and pollution source identification exercise along the Gin River. The objective of this paper is to present the Water Quality Modeling System prepared for Gin River and its effectiveness in protecting the catchment to effectively implement the Greater Galle WSS Water Safety Plan.

Key words: catchment, consumer, gin river, water safety plan

SECM/15/108

VIBRATION CHARACTERISTICS OF VARIOUS WIDE FLANGE STEEL BEAMS AND COLUMNS

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Abstract:
Vibration characteristics of steel framed structures are affected by accurate modelling of the mass and stiffness matrices of beam and column members. In this regards, wide flange sections are the most popularly used steel sections, and calculation of axial, flexural and shear responses of these sections become critical. In this study, a mixed formulation frame finite element is developed from three-fields Hu-Washizu-Barr functional. Consistent mass matrix of the element is obtained such that determination of vibration frequencies of members with varying geometry and material distribution is modelled without any need for specification of different displacement shape functions for each individual case. An accurate shear correction coefficient for wide flange I and H sections is taken into account in order to get closer match with exact solutions. Comparative study is undertaken by the use of proposed beam finite element solutions and 3 dimensional solid finite element analyses in ANSYS. Results indicate that proposed beam finite element can get fundamental and higher modes of vibration for varying aspect ratios of wide flange beams and columns.

Keywords: steel framed structures; wide flange sections; finite element modelling; vibration characteristics

SECM/15/109

EFFECT OF COIR GEOTEXTILE AS REINFORCEMENT ON THE LOAD SETTLEMENT CHARACHTERISTICS OF WEAK SUBGRADE

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Abstract:
Geotextiles are permeable fabrics which, when used in association with soil, have the ability to separate, filter, reinforce and drain. It is not only allows reduction in the thickness of the pavement on a soft subgrade by the reinforcement action of geotextiles but gives less maintenance problems for long-term use. Coir geotextiles are made from coconut fibre which is a natural material composed of ligno cellulose cell obtained from the husk of coconut.

This paper presents the strength aspects of woven coir geotextiles on weak subgrade. In this paper, the results of laboratory investigation on the load-deformation behavior of the road sections are summarized. Two different varieties of coir geotextiles H2M5 and H2M6 were used as reinforcement in pavement section. The static plate load test results provide evidence that the inclusion of H2M5 coir geotextile gives higher strength at lower deformation compared to unreinforced section. Also, horizontal tensile strain and vertical compressive strain values were determined using KENPAVE software. The result of KENPAVE analysis shown that the section reinforced with H2M5 coir geotextile has lower strains as compared to unreinforced and H2M6 coir geotextile reinforced sections.

Keywords: coir geotextiles, pavement, reinforcement, soft subgrade

SECM/15/110

STRESS-STRAIN BEHAVIOUR OF STRUCTURAL LIGHTWEIGHT CONCRETE UNDER CONFINEMENT

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Abstract:
In this study, stress-strain behavior of structural lightweight concrete is studied under unconfined and confined conditions. To this end, the use of naturally occurring perlite material as lightweight aggregate and cement replacement material is considered. Although there are several studies on the confinement effects on normal weight concrete, there is lack of data on the confinement behavior attained for structural lightweight concrete by spiral or stirrup reinforcement. In order to evaluate the performances of structural lightweight concrete and normal weight concrete in a reliable manner, an experimental study is conducted. Through the experimental study on cylinder specimens that are unconfined and confined in different percentages by spiral reinforcement, the elastic and inelastic, namely post-peak behavior of structural lightweight concrete is recorded by the use of displacement-controlled testing machine. The results indicate that concrete produced from perlite as lightweight aggregate as well as through the use of cement replacement material provide significant energy absorption in the presence of spiral reinforcement.

Keywords: structural lightweight concrete; natural perlite aggregate; cement replacement material; confined concrete behavior

SECM/15/113

DEVELOPMENT OF A COMPUTER MODEL OF A DRAINAGE SYSTEM WITH UNCERTAINTIES IN EXTERNAL INFLOW AND CHANNEL CROSS-SECTION

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Abstract:
In urban development, stormwater drainage is an important aspect of infrastructure planning and design. Computer modeling has often been used to assist the design of the drainage system. With this type of modeling, external inflows to the system and channel configurations are important model inputs. As such, it is challenging to develop a model when there are uncertainties in external inflows and channel cross-sections.

This paper presents the development of a computer model of a drainage system in Singapore. In the development, it is necessary to resolve the uncertainties in the external inflow at various points along the drainage system, as well as the uncertainties in channel cross- sections. The software package Stormwater Management Model (SWMM) was used and the model has been developed and calibrated with on-site measured data. The results show that the external inflows have significant effects on the simulated hydrographs, while channel cross-sections do not affect the simulated hydrographs. On the other hand, the channel cross-sections have significant effects on the simulated water levels in the drainage channels.

Keywords: modelling, stormwater, uncertainty

SECM/15/114

PLANNING & MITIGATION METHODS TO REDUCE THE PROJECT DELAYS IN SRI LANKAN CIVIL ENGINEERING CONSTRUCTION INDUSTRIES

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Abstract:
A construction project is commonly acknowledged as a successful project when the aim of the project is achieved in terms of predetermined objectives of completing the project on time, within budget and to the required quality standard. Delay in the completion of a construction project can be a major problem for contractors, consultants as well as for clients. These delays lead to costly disputes and adverse relationships amongst project participants. Projects can be delayed due to large number of reasons. The reasons are related to various types of uncertainties associated with activities during the construction process or during the planning and design stages. Project delays in general are due to delays caused by the client, delays caused by the contractors/consultants and delays due to equipment/materials & environmental factors. The objective of this research was to identify the major causes of construction project delays in the construction industries in Sri Lanka and find out how planning and mitigation methods would minimize their impacts. This study was carried out through questionnaire surveys and interviews conducted within the construction industry professionals in Sri Lanka. It is expected that this study would identify project planning deficiencies in the construction industry and propose recommendations to rectify identified issues and thereby reduce project delays which would contribute towards sustainable construction.

Keywords: construction delays, construction planning, project delays, project planning

SECM/15/116

DEVELOPMENT OF OPTIMAL BRIDGE MANAGEMENT SYSTEM CONSIDERING PRACTICAL USEFULNESS

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Abstract:
Several bridge management systems (BMS) have been developed to estimate the future expenditure for bridge management, but those have not been sufficiently applied to the practical bridge management for the reason of complex problem that the damaged bridge members should be repaired at one time as much as possible considering the whole bridge system. In this study, a useful BMS for practical bridge management is developed without special techniques. The deterioration transfer curves for slab, girder and abutment are introduced for three classifications of rapid deterioration, standard deterioration and no degradation members. The most economical repair plan is determined by comparing the life cycle costs for nine cases considering the annual budget limit. The effectiveness and practical usefulness of the system are illustrated by applying it to the bridge management of 1381 bridges in Fukui city, Japan.

Keywords: Bridge management system (BMS), deterioration transfer curve, optimum repair plan

SECM/15/117

BUILDING INFORMATION MODELLING IMPLEMENTATION IN PRACTICE: LESSONS LEARNED FROM A HOUSING PROJECT IN THE NETHERLANDS

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Abstract:
Real-world implementations of BIM can serve as use cases to demonstrate BIM implementation strategy in practice. This paper presents the findings from a case study of BIM implementation on a housing project in the Netherlands. It describes how BIM approach was used to facilitate the delivery of the project. The benefits and challenges encountered are discussed. The role of BIM process management, BIM activities and key enabling technologies are examined as well as the impact of procurement on BIM implementation. The paper highlights how BIM activities was structured to deliver the project faster (time), cheaper (cost) and better (quality and performance). The analysis is based on project documents and interview with those involved in managing the BIM process. One of the major implications of the findings is that: BIM implementation is a set of interrelated activities and processes. Organisations seeking to work using BIM approach need to actively engage with the process and, in an ongoing basis, learn from their experiences as well as improve based on the lessons learned.

Keywords: Building Information Modelling (BIM), case study, housing project, BIM implementation

SECM/15/118

APPLICATION OF WATER QUALITY SIMULATION FOR WATER SAFETY PLAN AT MAHAWELI RIVER BASIN, KANDY

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Abstract:
Water Safety Plan (WSP) is an effective risk assessment framework to elaborate possible risks for water supply systems. However, risk quantification of "severity" and "likelihood" of specific incidents is challenging especially for the risks at water sources. Water quality simulation is an essential tool for predicting the risks and applying effective countermeasures, while data availability and usability for practitioners remains as obstacles for implementation. The objective of this study is to develop appropriate simulation methodology for the risks at water source of all the water supply systems in Sri Lanka.

In this report, we focused on the Mahaweli river basin in Kandy. Reviewing the existing WSP at Greater Kandy WTP, the contamination of intake water by the leachate from neighbouring solid waste damping site was considered as a significant risk. We developed dynamic hydraulic model and water quality model which can configure input and output data on Microsoft Excel interface. As a result of the simulation, it was implied that the contaminant from the leachate can flow back to the intake of the WTP due to density flow. Re-risk assessment for possible countermeasures showed the structure modification and leachate treatment are effective to mitigate the risk for water quality hazards.

Keywords: risk assessment, raw water quality, water quality simulation, water safety plan

SECM/15/119

LANDFILL LEACHATE TREATMANT BY USING TWO STAGE ANAEROBIC AEROBIC SYSTEMS

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Abstract:
In Sri Lanka, the Municipal Solid Waste is disposed in to sanitary landfills or dumping sites. The generated leachate at dumping sites causes many problems leading to various social, cultural, environmental impacts. Hence, it is decided to conduct this research to find out suitable solution for proper treatment for the leachate generated at waste disposal sites. In this research, two stage biological treatment processes were used to treat the leachate. At first stage up flow anaerobic sludge blanket (UASB) is used. The important of the UASB is it removes high amount of BOD_5 and COD in efficiently. However the UASB process is not capable for removing fair amount of nutrients. To overcome this problem an aerobic system sequence batch reactor (SBR) was used after the UASB. The specific task of this introducing this SBR system is to study the capabilities of removing nitrogen in leachate treatment. In the total system, the BOD_5 removal efficiency is around 92% and COD removal efficiency is reached to 54%. Therefore this system can be used as secondary treatment system, to treat leachate.

Keywords: Municipal Solid Waste, Leachate, Biological treatment processes, UASB, SBR, Nirtogen removal

SECM/15/120

SEISMIC ANALYSIS OF GUYED MAST TOWERS IN SRI LANKA

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Abstract:
With the rapid development of the telecommunication sector in the country, telecommunication/broadcasting towers play a vital role in telecommunication and broadcasting sectors. There are many structural forms available for towers and guyed mast is one such type commonly seen in country sides of Sri Lanka where land is available for cheaper price. Moreover, in the case of very tall tower is needed, guyed mast is more economical solution than self-supporting towers. The failure of a guyed tower especially under a disaster situation such as earthquake is a major concern in many ways. One is the failure of communication/broadcasting may hamper the communication needs to carry out rescue and other essential operations. Further, failure of a tower may itself cause a considerable economic loss as well as damages to human life. Therefore, checking of structural performance tower under seismic and other extreme weather effects is quite vital.
Even though, Sri Lanka was believed to have no seismic threats, presently a strong argument is going on amongst the professionals regarding the seismic condition of our country with the reported earth tremors in recent times. Hence, evaluating the structural performance of existing telecommunication/ broadcasting towers under seismic loads is utmost important since almost all existing towers have not been designed considering seismic forces due to traditional belief that Sri Lanka will not be subjected to earthquakes of appreciable magnitudes.

Considering the above situation, assessment of structural performance of exiting Guyed mast towers (which were not initially designed considering earthquake loading) under possible earthquake loading was selected as the objective of this study. Accordingly, behavior of existing Guyed mast towers under seismic loading using ANSI/TIA-222-G tower design code was studied and results, observations and conclusions based on this analysis are presented.

Keywords: Guyed mast, seismic loading. Telecommunication towers

SECM/15/121

DESIGN PROCESS OF A SANDY CONVEX SHAPED BEACH LAYOUT

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Abstract:
The planned Colombo Port City (CPC) development, shown in Figure 1, comprises 450 acres of reclaimed land, 3 km of offshore breakwater, two additional breakwater revetments and a central canal. In its final stage, the reclamation will be closed off by a sandy beach at the seaward side. This beach will be partly sheltered by the offshore breakwater and lagoon in front of it. The beach layout is convex, implying that all beach angles are offshore directed. This layout with respect to erodibility, poses multiple design complexities. These problems will be tackled by a converging design approach, focusing on reduction of risks and increasing knowledge (from measurements and modelling) at the one hand and a highly adaptable design at the other hand. This engineering management approach is described in the present paper.

Sediment transport along the beach is influenced by the complex hydraulic climate in the lagoon area: the combination of wave overtopping and transmission through the breakwater, waves diffracting around the breakwater heads, local waves and residual currents. The anticipated sensitivity to beach erosion should not negatively affect the development. Therefore, to quantify the beach stability, the hydraulic climate inside the breakwater has been assessed by numerical modelling to form a basis for the spatially distributed sediment transport computations. To acquire a reliable translation from the offshore wave and current climate to the climate within the lagoon area, extensive physical and numerical model studies have been performed.

The preliminary beach stability analysis indicates that mitigation measures will most probably be required. This requirement, as well as assessment of the type of mitigation measures, is key to the adaptive engineering approach that has been adopted here. The adaptive approach aims at arriving at a practical design for the beach to secure the functional (public) requirements within economical (maintenance) and practical (constructability) boundaries. A groyne scheme is a relative simple and adaptive way to stabilize an unstable beach, whilst providing flexibility as it can be implemented in a phased way and be adapted rather simply when required. Along with the design, we focused on optimization of the construction strategy and sustainable material usage.
The present paper presents the numerical analysis part of the iterative design process, which has not yet been completed. As such, this paper is the launching paper regarding the CPC beach stability, providing a baseline for the design, and will be followed up by further paper(s) at a later stage of the design and construction.

Keywords: beach protection, Colombo port city, convex layout, erosion, sediment transport

SECM/15/122

COMPARISON OF DESIGN METHODS OF WATER RETAINING STRUCTUERES USING THE PROVISONS OF INTERNATIONAL CODES

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Abstract:
Durability and impermeability in a water-retaining structure are of prime importance if the structure is to fulfill its function over its design life. In addition, serviceability cracking tends to govern the design of water retaining structures. This research concentrates on load-induced cracking specifically that due to pure bending and to direct tension in water retaining structures. At present Sri-Lankan designers tend to use British standards in the design of water retaining structures. But today the countries in the world have adopted different codes with the belief that the code adopted will best fulfill the requirements in designing water retaining structures for their particular exposure. Even with the proper design using that selected code, a question arises about the acceptability of the design with regard to other international codes. Thus, Comparison of these international codes is of paramount importance. ACI 350M, AS 3735, BS 8007 and EN 1992-3 were the codes that were selected to do the comparison. Identifying the major contributors for cracking as flexure and direct tension load case according to the given procedure for each code to control cracking spreadsheets were developed. During the project several parameters were varied and by analyzing the obtained results, an effort was taken to evaluate the design approaches given in each code to control cracking.

Keywords: comparison of design methods, water retaining structures, control cracking, international codes

SECM/15/123

AN EXPERIMENTAL STUDY ON PRE-TENSIONED CONCRETE MEMBERS

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Abstract:
Prestressed concrete elements are highly being used in the construction industry. For these kind of precast members, exposure to the loading starts at the fabrication processes. There might be high level of stress fields inside the element because of the prestressing. Exact values of these stresses are being assumed according to the linear homogenous design criteria. However, modeling a pre-tensioned prestressed concrete member via photoelastic experimental procedure could lead to make exact stress analysis in a pointwise manner. The analogy between the prestressing phenomena with photothermoelasticity led to make a pretensioned concrete model with using the "frozen-stress" method of photoelasticity. Two sorts of three-dimensional photoelastic models are prepared and analyzed with using the experimental techniques of three-dimensional photoelasticity and aimed to deal with the investigation of the pre-stress distribution after the fabrication process of the pre-tensioned reinforced concrete members. With considering the technical literature, insufficient information requires to make an investigation of the stress distribution at the vicinity of the free edges and bonding area of the reinforcing material of the pre-stressed structural members. Finally, obtained results show that some regions in a prestressed member have to endure high level of compressive and shear forces immediately after the release of prestress. This study mainly deals with the determination of the critical regions in a prestressed member and taking some precautions in order to keep the safe design margins.

Keywords: Pretensioned concrete, photothermoelasticity, photoelastic modelling, anchorage zone

SECM/15/124

EXPERIMENTAL INVESTIGATION OF PERFORMANCE OF REEF BREAKWATERS

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Abstract:
Reef breakwater is a low crested, rubble mound breakwater without a conventional multilayered cross section. It has been identified that transmission coefficient is one of the main parameters to quantify the performance of reef breakwaters and several parameters that influence transmission coefficient was identified. Accordingly, a comprehensive laboratory investigation was carried out and transmission of different reef breakwaters was studied by varying different influence parameters. It was observed that wave steepness, crest width and depth of crest submergence are the most influential parameters on transmission coefficient. Comparison between existing equations to calculate transmission coefficient was done using data from the present study. When using existing equations for the same input parameters, it can be seen that estimated transmission coefficient values differ from each other suggesting that their applicability to a real life problem is questionable. Therefore a new improved formula to estimate transmission coefficient was derived using dimensional analysis incorporating more influence parameters than existing equations. This formulation proved to be better than the previous equations.

Keywords: Reef breakwaters, Transmission coefficient, Physical model tests.

SECM/15/125

ATTERBERG LIMITS ESTIMATION OF PILANI SOIL USING ULTRASONICS

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Abstract:
Depending on water content, four physical states of soil consistency are used. The water contents at which soil undergoes physical state change are called Atterberg limits. Liquid as well as plastic limit are two commonly used Atterberg limits and are used extensively, either individually or together, with other soil properties to correlate with engineering behavior such as compressibility, compactibility, shrink-swell and shear strength. Conventional method of liquid limit determination requires test to be conducted at 5 (at least) different water contents for accurate estimation. Even liquid limit estimation using cone penetrometer requires experiment to be carried out at more than one water content. Same is applicable for plastic limit estimation. Sand content has effect on its liquid and plastic limit, as well as pulse velocity through it. Consequently, it should be possible to estimate liquid and plastic limit by knowing pulse velocity through it. Pulse velocity using through transmission technique (at constant water content and density); as well as their liquid and plastic limits using conventional techniques at varying sand content were determined and plotted for Pilani soil. This plot can be used as calibration curve for aforementioned estimation purposes and can be developed for other region soils as well.

Keywords: atterberg limits, calibration curve, soil behavior, through transmission technique, ultrasonic pulse velocity

SECM/15/127

OPERATIONAL BEHAVIOUR OF HYDRAULIC STRUCTURES IN IRRIGATION CANALS IN SRI LANKA

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Abstract:
The Hydraulic performance of structures provided for regulation in irrigation canals is influenced by many parameters such as type of flow control, type and frequency of adjustments, and topographical features of sub-systems that they are installed. The irrigation systems in Sri Lanka mostly designed for up-stream discharge control operation, with manually/mechanically adjusted gated structures, under steady state flow conditions. Further, topographical features of many gravity irrigation systems are varying at sub-system level due to presence of single and double bank reaches, inclusion of in-lined storage tanks. However, irrigation systems are operated under varying flow regime due to scheduled or unscheduled flows in water delivery. The adjustments of gates in structures in such situations are done by manually/mechanically by operators at different frequencies.

Therefore these situations are analyzed by hydraulic simulations using SIC hydraulic model for three different topographical sub-systems under different frequency of adjustments. The actual performance in water delivery is evaluated by effective volume of water delivered, timeliness in water delivery, at the final delivery location while maintaining on-line water adequacy through delivery points along the canal. The results will provide guidance for operation of regulation structures for effective conveyance of water under varying flow conditions.

Keywords: canal irrigation, canal operation, canal regulation

SECM/15/129

IMPORTANCE OF QUALITY FOR CONSTRUCTION PROJECT SUCCESS

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Abstract:
Construction projects are always expected to create a balance between cost, time and quality. It is possible to have high quality and low cost, but at the expense of time, and conversely to have high quality and a fast project, but at a cost. High quality is not always the primary objective for the client; however, it is extremely important to a successful project. An appropriate level of quality could be determined during all phases of the construction project. Specially, construction and commissioning are two critical phases where the project could impact by its operability, availability, reliability, and maintainability of a facility. Ultimately, a facility with a good construction quality program and minimal defects is more likely to have a smooth and trouble free transition into the commissioning and qualification phase of the project. This creates a great potential for quality improvements in construction projects, as the poor quality could negatively effect to project failures. Therefore, the purpose of this research is to investigate the importance of quality for construction project success. Accordingly, quality and related key literature were reviewed and a framework of quality for construction project success was developed.

Keywords: quality, construction projects, success, importance

SECM/15/130

RC JACKETING ON RCC FRAME OF OVERHEAD WATER TANK USING RESULTS OF NON DESTRUCTIVE TESTING - A CASE STUDY.

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Abstract:
A three storey RCC frame of an old overhead water tank in BITS Pilani campus had developed wide visible cracks, rusting of steel reinforcement and concrete spalling conditions at many locations. The condition of these structures was assessed by visual inspection, non-destructive testing (NDT) like rebound hammer, ultrasonic pulse velocities, rebar locator etc. and laboratory tests, to ascertain their suitability for further use. Based on the results of the tests conducted RC jacketing technique using anti corrosive agent, micro concrete and polymer modified mortar for retrofitting was suggested and implemented. The NDT was conducted again after the completion of retrofitting of the structure. This case study presents the use of standard and innovative repair materials, appropriate technology, workmanship, and quality control for successful repair, strengthening and restoration of damaged structures.

Key words: Retrofitting, Non-destructive testing, Rebound Hammer, UPV, rebar locator, micro-concrete, RC Jacketing

SECM/15/131

ADOPTION AND SCOPE OF BUILDING INFORMATION MODELLING (BIM) IN CONSTRUCTION INDUSTRY OF PAKISTAN

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Abstract:
Building Information Modelling "BIM" is becoming a better known established collaboration process in the construction industry. Owners are increasingly requiring BIM services from construction managers all over the world, but the adoption of BIM in building construction industry of Pakistan is very slow. Globally one of the great advantages of BIM is the ability to create an accurate model that is useful throughout the entire life of the building, from initial design through occupancy and operations. The benefits of BIM are evident in its capability. There are two objective of this research work, first to identify the problems faced in construction management and secondly to identify the barriers in adoption and implementation of BIM in local building construction industry.

The research objectives were achieved through literature review, case studies, and questionnaire. First, the research identified the uses of Building Information Modelling for construction industry, and then identified the problems faced by construction managers in construction management. On the basis of literature review a questionnaire was prepared and surveyed to identify the source of construction management problems in the building construction industry of Pakistan. Then, the project examined the uses and benefits of BIM in the construction of a research facility by minimizing the sources of many identified problems in questionnaire survey. Finally, the project concluded and recommended the ways to increase the use of BIM in building construction industry of Pakistan.

Keywords: BIM, Construction Industry, Construction Management, Labour Productivity

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ADOPTION AND SCOPE OF BUILDING INFORMATION MODELLING (BIM) IN CONSTRUCTION INDUSTRY OF PAKISTAN

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Abstract:
Project management is today a current and highly discussed area. How projects within the construction industry are managed has not changed significantly during the last decades. The construction market, the number of different actors and the way that projects are procured today has however changed. This has led to a gap between the managerial view on how construction projects should be conducted today and how they actually are executed. This is reason enough to question this conservative industry and look into what possibilities there might be in the future. The Agile project management approach evolved from the software industry where it has grown and developed through empirical progress.

The objective of the research is to identify and understand the challenges and opportunities confronting the Pakistani construction sector and to investigate ways to implementing the agile approach. The research will identify the changes that are necessary to meet the industry's performance requirements. The Agile approach almost forces the client to increase their participation in the project compared to the situation today. It can also decrease uncertainty and improve risk management.

Keywords: agile management, construction management, dynamically complex projects, traditional project management

SECM/15/134

BROKEN WAVE LOADS ON A VERTICAL WALL: LARGE SCALE EXPERIMENTAL INVESTIGATIONS

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Abstract:
Many storm protecting structures (eg. seawalls) are increasingly built at the back of the beach such that breaking waves are unlikely to reach them during the normal sea state. These structures are predominantly subjected to broken waves under most severe storm and tide conditions. Detailed studies relating broken wave forces to the incident wave parameters and beach slope are lacking. Therefore simplified assumptions are used to estimate the design loads due to broken waves. This knowledge gap has motivated to investigate the broken wave impact loads on coastal structures. A series of physical model experiments were carried out in the Large Wave Flume (GWK, Hannover, Germany) in order to measure the broken wave impact loads on a vertical wall. This paper describes the experimental results in detail. Based on the measured forces, a simple empirical formula is derived in terms of the wave parameters.

Keywords: broken waves, broken wave impact, impact pressure, vertical wall

SECM/15/135

INCORPORATING RECYCLED PET FIBRES FOR CONCRETE CYLINDRICAL CULVERTS

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Abstract: Fiber reinforced concrete is one of the prominent solutions for many problems that concrete had from its early stage. Polyethylene terephthalate (PET) fiber is a sustainable solution for fiber reinforced concrete since it makes fiber material an eco-friendly material. It's a well-known fact that steel reinforced concrete is vulnerable to corrosion. It is accelerated in the water conveying elements such as concrete pipes. So usage of PET fibers as a replacement material for steel reinforcement cage in reinforced concrete pipe element would definitely have a long life. At the initial stage concrete cubes were casted with different fiber compositions for water cement ratio of 0.3 and 0.45.From that it has observed that 2% of PET fiber would give the optimum result for concrete having 0.3 water cement ratio. Three sets of specimens (plain concrete, Reinforced concrete and PET fiber concrete) were subjected to three-edge-bearing test. It was identified that PET fiber reinforced concrete is the most applicable method for production of concrete pipes. Because manufacturing of the cage form of the conventional reinforcement bars adjusted for concrete pipes requires special bending, welding, and placement machinery, and also it is time-consuming. PET fibres of standard sizes, on the other hand, can be added to the pan-mixer of any concrete plant as if they were another aggregate or mineral admixture. Without any extra process modification, PET-fibre concrete can be produced and cast in the moulds similar to the ordinary plain concrete. Therefore it can be declared that PET-fibre concrete pipes seem to be an economical alternative to the classically-reinforced-concrete pipes.
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Keywords: Recycled PET, PET Fiber reinforced concrete, cylindrical culverts, three edge bearing test

SECM/15/137

ENHANCED PERFORMANCES FOR MARSHALL PROPERTIES OF HOT MIX ASPHALT (HMA) BY INCORPORATED 60/70 GRADE OF BITUMEN

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Abstract:
During the last decade, the rehabilitation and improvements of road networks in Sri Lanka exhibited a rapid development. As a result many of roads were undergone for new asphalt surfacing with hot mix asphalt, at least a wearing course, and the black top. However, with this rapid development, few premature failures were also observed in many of these newly constructed asphalt roads covering all part of Sri Lanka. Pre-mature cracking, removal of top thin film of wearing layer, bleeding and localized failures were among them. Bitumen played a very important role in hot mix asphalt and improvement for bitumen can enhanced the improved properties of HMA significantly. In this research, instead neat 60/70 grade of bitumen, it was used modified 60/70 grade, with Nano silane, enhancing anti-stripping and bonding capabilities. Research was comprised three stages of testing, lab trials, plant trials and filed trial in Colombo-Kandy road section. Results showed significant improvement for marshal properties. The stability and flow increased by 24% and 35 %, respectively. The anti-stripping property was also increased significantly, even after 6 hr, boiling test, it showed elevated no of coated aggregates. In addition, the mix was very well after few weeks, and very sticky condition proved that the strong bonding ability. All enhanced characteristics can be caused to exhibit improved performance and can be lead to extended life period of road construction.

Keywords: Anti-Stripping, Hot Mix Asphalt, 60/70 grade Bitumen, Marshal Properties.

SECM/15/138

INVESTIGATION OF STRENGTH PARAMETERS AND PHYSICAL PROPERTIES OF NON-CLASS TIMBER SPECIES IN SRI LANKA

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Abstract:
Timber is a commonly used construction material in Sri Lanka. But the strength parameters of locally available non-class timber are not available. In this study main objectives are to determine strength parameters and physical properties of selected local timber materials and to develop a strength class classification with their possible applications in the construction field. Different strength parameter tests are conducted in bending, compression (grain parallel and perpendicular), tension (parallel to grains), and shear perpendicular to grain. In addition, durability, fire resistance tests and physical properties such as dry density, bulk density, and water absorption were carried out. For those tests BS 373 (1957) and EURO CODE 5 were used as references. Average moisture contents of non-class timber specimens were around 12%, modulus of elasticity varies 3200 MPa - 13,000 MPa, modulus of rupture varies 37 MPa – 85 MPa, dry density varies 600 kg/m3 - 900 kg/m3. Strength parameters at serviceability limit, mainly compressive strength at parallel to grains varies 13 MPa - 45 MPa, and compressive strength perpendicular to grains varies 3 MPa – 22 MPa in most of the non-class timber species. Shear capacity of perpendicular to graons of non-class timber materials varies 0.9 MPa - 5 MPa at serviceability limit. Tension capacities of timber materials vary 35 MPa - 100 MPa and charring rate of timber species varies 0.25 mm/min - 0.8 mm/min. Similarly other test parameters were investigated and presented in the paper. Finally identified non-class timber species were classified according to available strength classes and proposed suitable applications for each type.

Keywords: non-class timber, strength classes, compression, tension, durability, fire resistance

SECM/15/139

EFFECT OF RICE HUSK ASH (RHA) ON STRUCTURAL PROPERTIES OF FIRED CLAY BRICKS

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Abstract:
In Sri Lanka, some amount of rice husk has been used as a fuel to fire bricks. However, rice husk ash (RHA) produced from the brick firing process has not yet been utilized effectively. Objective of this study is to utilize the rice husk ash wasted from the brick kiln to enhance structural properties of fired clay bricks.

Rice husk ash was collected from the brick kiln, located in Embilipitiya area, while the clay was collected from Dankotuwa area, where a brick manufacturing has been well established. Sieve analysis was performed for the collected RHA to identify the particle size distribution. The clay was mixed manually with different percentage of RHA: 0%, 2%, 4%, 6%, 8% and 10%. Atterberg limit of the mixture was investigated in order to identify suitability of the mixture for brick production. Bricks having a size of 195mm x 95mm x 50mm were cast manually and kept for drying. All the bricks were fired in a brick kiln. The burning temperature was within the range of 600 oC to 850 oC. Compressive strength and water absorption of fired bricks were investigated.

All percentages of addition of RHA improve the mixture for brick manufacturing. The optimum compressive strength of 3.55 N/mm2 was found at 4% of addition of RHA. It was found that 32.7% improvement in the compressive strength of the bricks with 4% RHA addition compared to the control bricks (i.e., fired clay bricks with 0% of RHA), implying that RHA wasted from the brick kiln can be effectively used to improve the structural properties of the fired clay bricks.

Keywords: Rice Husk Ash (RHA), burnt clay bricks, compressive strength, water absorption, silicon aluminium ratio

SECM/15/140

BOND STRENGTH BEHAVIOR OF HEADED REINFORCEMENT BAR WITH VARYING EMBEDMENT LENGTH

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Abstract:
Headed reinforcement is a relatively new product and has not been used in many applications. Headed reinforcing bars have been extensively used in the construction of offshore oil platforms where hooked bars have traditionally been used to anchor longitudinal reinforcement or bars bent for ties and transverse reinforcement. Hooks and bent-bar ties create a large amount of congestion in the reinforcing cage which leads to difficulties during construction. Using headed reinforcement removes the tail extensions of hooks and allows fewer larger bars to be used, greatly reducing the congestion of the reinforcing cage. It has been found that the use of headed reinforcement can greatly decrease the time needed to erect the reinforcement resulting in large cost savings. Headed reinforcement has also been used in a few projects for strengthening and repairing footings of highway structures.

A total 81 Pullout test were performed to the study of Bond behavior of Headed reinforcement bar in concrete with different Embedment length with various diameters of bars, various grade of concrete and various sizes of cubes.

In this research project, it is proposed to execute experimental work by using headed reinforcement bars. The effect of different parameters like embedment length, head shapes and concrete grades, threaded headed reinforcement bars can be study. The results will be used to develop design recommendations for the application of headed reinforcement bars.

Keywords: headed reinforcement; pullout; embedment length; diameter of bars.

SECM/15/141

EVALUATING SUBCONTRACTOR PERFORMANCE IN CONSTRUCTION INDUSTRY

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Abstract:
Most of the construction projects undertaken are more complex in nature, demanding greater skills and technologies. In the past two decades, subcontracting has been utilized extensively in construction industry. Hence, subcontractor is a key person to assure the success of a construction project although many issues involved in subcontracting practice and rarely acknowledged. The reliance of main contractors on subcontractors to execute major portions of construction work makes the success of construction projects highly susceptible to the performance of subcontractor organizations. Early researches picked out those subcontractors are not being fully utilized due to various issues. As a result, subcontractors are subjected to put tremendous pressures on project performance in terms of quality, time and cost in construction industry. Therefore, in construction industry, there is a gap between the required performance level and the current performance of subcontractors. Thus, this study attempts to fulfill the gap between required and current performance of subcontractors by investigating subcontractors' issues on the project performance in terms of time, cost and quality. Literature review indicated number of issues with subcontractors that had adversely influenced the performance of a construction project. The study was adopted survey approach to fulfill the research objective. The structured questionnaire which was developed by supporting literature findings was distributed among main contractors and sub-contractors. Relative Important Index was adopted to analyse and evaluate the collected data. The results revealed that, selection method, critical site coordination, labour migration, delay payment and site safety were respectively significant on subcontractor performance. Further, it was identified there is a positive relationship between attitudes of main contractor and subcontractor. The paper describes the mitigation measures that could be used to maximize the performance of construction projects in terms of time, cost and quality, while enhancing the performance of subcontractors.

Keywords: Construction Industry, Subcontractor Performance, Project Performance, Issues

SECM/15/142

APPORTIONMENT AND RANKING OF RISK ELEMENTS IN CONSTRUCTION INDUSTRY OF SRI LANKA-CONTRACTORS' PERSPECTIVE

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Abstract:
This study provides the results of a survey of major contractors engaged in the Sri Lankan construction industry. It is aimed at identifying common risk elements affecting construction industry projects, determining how they are apportioned between the owner and the contractor, and quantifying and ranking their significance. The previous studies provided a list of 52 risk elements and with the help of a pilot study it was reduced to manageable 25 risk elements having a great relevance to the Sri Lankan construction industry. Altogether 72 respondents selected from among major contractors in Sri Lanka (C1 to C4) were involved in the questionnaire survey of the study.

The analysis of the results show that only some risk elements are apportioned more to one party (apportionment of at least 65%) either contractor or owner. Shortage of labor, materials, tools and equipment (82%), Low productivity of labor and equipment due to complexity of work (78%), Labor disputes & trade union action (76%), Delays due to sub contractors, suppliers and other bodies (74%), Difficulty to coordinate with sub- contractors (74%), Corruption (70%), Delayed payment by owner (68%), and Accidents (66%) are apportioned more to contractors whereas, Delay in approvals and permits (70%), is apportioned more to the owner than to the contractor. The risk elements were ranked according to their significance and the most significant risk elements are, in descending order of significance are; Shortage of labor, materials, tools and equipment, inaccurate and incomplete design, Financial failure resulting from owner and contractor, Substandard quality of work. The results indicate that contractors perceive that risks are apportioned disproportionately more towards them. The implication of this is that naturally contractors tend to quote higher bid prices to cover their potential risks.

Key words: construction risks, risk management, Sri Lankan construction industry

SECM/15/143

USE OF RICE HUSK ASH BLENDED CEMENT TO MANUFACTURE CELLULAR MASONRY BLOCKS

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Abstract:
This paper summarises the research work on determining suitability of rice husk ash (RHA) to partially replace cement in manufacturing cellular masonry blocks. The particle size distribution and chemical composition of RHA were measured for samples taken at different temperatures. In this research, mixtures have been prepared in combinations of four binder-sand ratios namely 1:3, 1:4, 1:5 and 1:6, three water-binder ratios namely 0.4, 0.5 and 0.6 and five levels of cement replacement with RHA namely percentages of 0, 5, 10, 15 and 20 by weight. One hundred and twenty cubes were cast (4x3x5x2=120) and tested for compressive strength at 7 and 28 days. Based on the compressive strength values, 1:5 binder-sand ratio was chosen as the appropriate mix proportion to cast cellular masonry blocks for different water-binder ratios namely 0.5 and 0.6 as per SLS 855Part 1:1989.

RHA was blended with cement in percentages of 0, 5, 10, 15 and 20 by weight in producing cellular masonry blocks of size 390 x 190 x 200 mm. These were tested for water absorption in addition to compressive strength. The compressive strengths of cellular masonry blocks at 7, 14 and 28 days for 1:5 binder-sand ratio, water-binder ratio 0.5 and 5 per cent cement replaced with RHA were 2.05 N/mm^2, 2.24 N/mm^2 and 3.37 N/mm^2 respectively. Likewise the values for 1:6 binder-sand ratio for water-binder ratio 0.5 and 5 per cent cement replaced with RHA were 1.6 N/mm^2, 2.18 N/mm^2 and 3.24 N/mm^2 respectively. The minimum compressive strength as per SLS 855 Part I: 1989 is 1.2 N/mm^2. The water absorption rates for water-binder ratios 0.5 and 0.6 are 9.8 and 10.5 respectively, which are within limits; the allowable limit is 10-15% as per BS EN 1996-1-1. The study concludes that 15 per cent cement replacement level is permissible.

Key words: rice husk ash, cellular masonry blocks, blended cement

SECM/15/144

THE USE O FLEXIBLE FLAPS IN IMPROVING THE SETTLEMENT RESISTENT BEHAVIOUR OF FOUNDATION

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Abstract:
Today shallow foundation construction in soft soils faces many problems due to low bearing capacity of soft soil. Although deep foundations can be used as an alternative, considering the costs and the time involved, the approach is proven to be uneconomical. This has led many researchers to design innovative shallow foundation systems for construction on soft soils, with adequate bearing capacity, while minimizing the settlement. Two such foundations are the "Cakar Ayam foundation" and "Akar foundation", which are currently used in construction industry in countries like Malaysia.

Two vertical flexible flaps attached to the underneath of a raft were used as a modified foundation model in this project to see it the foundation is capable of reducing the settlement when built on soft soil. The physical models of the modified foundation were built by varying the flap length and tested under different loads. Further, the models were analysed using finite element package, PLAXIS. The results obtained from physical modelling and finite element analysis showed that the foundation can be used to reduce excessive settlement on soft soil. The settlement reduces with the increase of flap length. Finally, the results verified that the modified foundation can be used as a temporary foundation to build a working platform for construction vehicles to pass through the working site.

Keywords: settlement, flexible, foundations, raft, flap

SECM/15/145

INVESTIGATION ON WHOLE BODY VIBRATION EXPOSURES OF OPERATORS OF CONSTRUCTION VEHICLES

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Abstract:
There is a growing interest in the areas of increased comfort and reduced vibration exposure levels in construction vehicles. It is necessary to understand the level of Whole-Body-Vibration (WBV) exposure since it affects comfort and health performance of humans. Objective of this study is to investigate the exposure levels in operators of construction vehicles. In addition, preventive strategies, which are needed to reduce low back pain problems due to WBV, will be investigated.

Ten operators of vehicles were selected where the vehicles were chosen so that those are vastly used in the construction sector. In this study, it was selected three construction vehicle types: excavators, backhoes and roller vibrators. A questionnaire survey was carried out with each operator regarding their profession, age, working experiences, health and exposure duration. The vibration exposure levels induced on operators bodies were measured using a tri axial vibration meter (SV 106) attached to a seat pad accelerometer. The operator was instructed to sat on seat-pad accelerometer and WBV exposures in three directions (i.e., vertical, fore-and-aft and lateral) were measured. It was found that the vibrational effect on vertical direction is more dominant than the other two directions (i.e., lateral and fore-and-aft). Measured vibration exposure levels were assessed based on recommendations given in ISO 2631:1997 and are presented in the paper.

Keywords: Excavators, backhoes, roller vibrator, Seat pad accelometer, Occupational health, ISO 2631-1 and EU directive 2002/44/EC

SECM/15/146

INVESTIGATION ON GROUND VIBRATION INDUCED BY CONSTRUCTION TRAFFIC AND NORMAL TRAFFIC

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Abstract:
With the development of infrastructure facilities all over the country, many construction activities are carried out causing the construction traffic increased. As a result of movement of heavy vehicles, people feel annoyances so that many complaints against this construction traffic have been arisen. Objective of this study is to investigate the characteristics of the ground vibrations induced by construction traffic and normal traffic.

A road construction site and a road near to stone crusher were selected. Ground vibrations induced by five dump trucks and one vibrating roller at 1m away from the edge of the road were measured using the four channel seismograph. Ground vibration levels experienced during period of construction traffic were greater than that for normal traffic and dominant in vertical direction. When operating a dump truck, Peak Particle Velocity (PPV) of the ground vibration in the vertical direction was in the range of 0.127-1.400mm/s while transverse and longitudinal directions ranges were 0.079-0.730mm/s and 0.127-0.825mm/s, respectively. Maximum vibration range experienced was 2.70-4.16mm/s induced by vibrating roller in vertical direction. Their transverse direction and longitudinal directions vibrations levels ranged from 1.41 mm/s to 2.05mm/s and from 1.49 mm/s to 3.35 mm/s, respectively. Vibrations induced by passenger vehicles ranged from0.079 mm/s to 0.143mm/s in all three directions. People may feel annoyances from construction traffic because the construction traffic moves continuously and induced greater PPV compared with normal traffic.

Key words: Construction traffic, Ground vibration, People annoyance, Seismograph

SECM/15/147

STUDY ON MODERN METHODS OF CONSTRUCTIONS USED IN SRI LANKA

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Abstract:
With the end of world war two, the demand for building construction increased together with inadequate supply of traditional constructions. To cater the increased demand the modern methods of constructions (MMC) came to practice as it yields high quality and less construction time. Nowadays the off-site MMC play a significant role in construction industry worldwide in terms clients' fundamental needs by restraining problems in traditional brick, block constructions. However, the application of MMC seems limited and few building constructions have used MMC in the Sri Lankan construction industry. This research therefore aims to explore current practice of off-site MMC in Sri Lankan construction industry and identify the barriers in adopting MMC.

Questionnaire survey has been carried out among 33 respondents including engineers, quantity surveyors and project managers to identify the applicability of off-site MMC and barriers in using off-site MMC. Data which have been gathered through the questionnaire survey have been analysed through statistical analysis and investigated that volumetric constructions are mostly used for single storey temporary buildings, hybrid constructions are mostly used for single storey office and temporary buildings while panelised constructions are highly used for single storey industrial and temporary buildings and sub-assemblies are mostly used single storey office and commercial buildings. Furthermore main barriers in implementing all above mentioned methods are public perception and poor awareness.

Keywords: Hybrid construction, modern methods of construction, Sri Lanka, volumetric construction.

SECM/15/148

INVESTIGATION ON HAND ARM VIBRATION EXPOSURES OF OPERATORS IN CONSTRUCTION INDUSTRY

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Abstract:
Hand arm vibration syndrome, also known as the white fingere effect, has become one of the most significant diseases seen in construction industry. A long term exposure of arms to high vibration levels causes to the vibration syndromes. Investigation of exposure levels associated with the hand arm vibration is necessary to prevent the white finger syndromes.

Objective of this research is to evaluate the vibration exposure levels which transfer through the human arm to the human body while engaging in civil engineering construction activities. Ten operators in civil engineering construction sites were selected as a study group. A questionnaire survey was conducted with the operators to identify whether they are diagnosed with hand arm vibration syndromes, their experiences and age. Vibration exposure levels transferred through the arms to the human body were measured using a vibration meter (SV 106) with a mounting tri axial accelerometer. It was found that operators were not aware about the vibration related syndromes, although they were exposed to the excessive vibration. Measured exposure levels were evaluated based on the standards.

Keywords: Hand arm vibration White figure effects Exposure levels Tri axial vibration meter

SECM/15/149

INVESTIGATION ON CHARACTERISTICS OF NOISE INDUCED BY CONSTRUCTION TRAFFIC

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Abstract:
Construction traffic noise continues to grow and it is accompanied by an increasing number of complaints from people exposed to the noise. The historical dimension of noise pollution in urbanized society identified 'noise' as being unwanted or undesirable sound created by construction vehicles that are considered harmful to human health and quality of life. The most important issue is sleep disturbance. However, the assessment of construction traffic noise is highly complex. Objective of this research is to determine the characteristics of noise induced by construction traffic and normal traffic. Sound levels were measured by using Sound level meter (SVAN971) and four channel seismograph at different locations near roads where heavy construction vehicles such as ABC truck, empty truck, roller and motor grader passing through. In order to compare with ambient condition, noise induced by normal vehicles (i.e., car, three-wheeler, van, bus) was also measured. Most of the construction vehicles induced noise, which are higher than the noise induced by the normal vehicles. Among the normal traffic, three-wheelers produce noise greater than other normal vehicles. It was found that construction traffic induced noise as high as 109 dB ($L(A)_{max}$),79.2 dB ($L(A)_{eq}$). Construction traffic produces noise at relatively low frequencies with high amplitude**.** Low frequency noise can be easily transmitted through structures and it can cause windows and other elements to rattle. The noise with tonal or impulsive characteristics is likely to be more annoying than noise without such characteristics.

Keywords: construction traffic noise, environmental impacts, noise pollution, sleep disturbance, noise annoyance

SECM/15/151

INVESTIGATION ON IMPROVEMENT OF LOW COST NERD SLAB SYSTEM

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Abstract:
The NERD center floor slab system was introduced by late Dr. A.N.S. Kulasinghe in early 1987 specially for domestic buildings which are used by middle income families in Sri Lanka. The invention of NERD system directed to identify cost effective slab construction system relative to conventional slab system and also the use of un-propped construction technique and reduction of depth of slab caused to reduce construction time and material required for construction activities. The NERD system consists with 50 mm thick in-situ concrete slab retain on trapezoidal shape pre-stressed beams which are placed by keeping 600 mm interval between each. Although, the concept of NERD system is being widely adapted in domestic building construction exposed beam under the soffit of the slab keeps away people from the use of NERD slab system. Therefore, this research has been given much more advertency to make it as flat soffit slab with the improvement of structural arrangement of the NERD system such a way that changing the shape of pre-stressed beam and thickness of in-situ concrete slab with hollow arrangement to reduce utilized concrete of the slab.

Keywords: Cost, Deflection, Flat soffit, Pre-stressed, Strength

SECM/15/152

POTENTIAL OF SRI LANKAN APATITE AS A FLUORIDE REMOVAL AGENT FROM AQUEOUS SOLUTION AGAINST VARIOUS APATITE MATERIALS

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Abstract:
As reported Sri Lanka it has a high fluoride contaminated ground water which was suspected as a cause for chronic kidney failure and there is an urgent need to treat fluoride contaminated drinking water to make it safe for human consumption by a low cost and convenient method. In this study potential of using Sri Lankan Apatite (SAp) as a defloration agent was studied and results were compared with other apatite materials. Adsorption experiments were performed on SAp, Sulphuric treated SAp (SSAp), Chicken bone char (CBC) and pre Hydroxyl Apatite (HAp). Since the raw SAp had no adsorbing capacity of fluoride, it was treated with sulfuric acid to produce HAp, however, sulphuric acid treatment for SAp did not yielded enough amount of hydroxy apatite as a fluoride adsorbent. Accordingly, higher leaching of fluoride into the solution was confirmed by the SSAp than that by the SAp. The fluoride removal capacities were in the order: HAp > CBC > SAp>SSA. The adsorption of fluoride by HAp and CBC was not well expressed by Langmuir isotherm but by Freundlich isotherm. It showed that HAp and CBC was a promising material for fluoride removal, therefore SAp should be further treated to extract phosphates to produce synthetic hydroxyapatite.

Keywords: Hydroxyl apatite, Apatite, Bone char.

SECM/15/153

PREDICTION OF RESIDUAL BUCKLING STRENGTH IN CORRODED STEEL BRIDGE MEMBERS

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Abstract:
At present, degradation process of steel bridges has become major problem in all over the world. Steel bridges are exposed to numerous degradation processes during long year operation period, which causes various types of defects. Corrosion is one of major cause of deterioration process of steel bridge structures. Because of the corrosion, remaining load carrying capacities of steel bridge structures are gradually decreased. So it is very important to carefully evaluate the remaining strength of steel bridges in order to understand the feasibility of those steel structures for the current usage and to evaluate the necessity of retrofitting of selected corroded members to strengthen the existing structures. There are lots of researches have been conducted in order to find out remaining tensile strength of corroded steel bridge members. To find out remaining buckling strength of corroded steel, previously conducted tensile test results are not accurate. So evaluation of buckling strength is an essential source of information for carrying out a comprehensive evaluation of its current buckling strength capacity and also the parameters involve in the method should be easily measurable.

There is a need of more brisk and accurate assessment method which can be used to make reliable decisions affecting the cost and safety. This study proposes a new method to calculate the remaining buckling strengths by using minimum thickness ratio based on the results of many buckling strength tests conducted on specimens of corroded steel bridge plates with different corrosion conditions based on the results of many compression coupon tests of actual corroded plates. And also, it is an impossible task to predict remaining buckling strength capacities of each and every aged bridge structure by conducting experiments and so nowadays, the finite element analysis method has become the most common, powerful and flexible tool in structural analysis and makes it possible to predict the strength of complex structures more accurately than existing classical theoretical methods. Further, since it is not easy to measure several thousands of points, to accurately reproduce the corroded surface by numerical methods and to predict their buckling behaviours, a simple and reliable analytical model is proposed by measuring only the maximum corroded depth ($t_{c,max}$), in order to estimate the remaining strength capacities of actual corroded members more precisely.

Keywords: Corrosion, Remaining buckling strength, Steel bridges, Finite element analysis

SECM/15/154

DEVELOPMENT OF AN INTEGRATED SOFTWARE TOOL FOR WHOLE OF LIFE MANAGEMENT OF CONCRETE STORM WATER PIPE ASSETS.

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Abstract:
In Australia, there are 500 local councils, each managing 300-1000 km of storm water drainage systems. Majority of the storm water pipes are concrete and are built in 1960's. Currently the councils use CCTV inspections to assess around 10% of the network and make maintenance decisions for the whole asset stock. This creates a major challenge for asset managers since the decisions are made based on assumed levels of deterioration. Catastrophic failure of pipes due to inefficient management will lead to flooding, which can be a major hazard to the community and infrastructure.

The paper presents the outcomes of a study conducted to assess the whole of life performance of concrete storm water pipes. Data from CCTV inspections are converted to a discrete rating and are used to derive Markov chain based deterioration models for the network. Based on these, optimized inspection strategy is developed for the pipe assets combined with a life cycle costing module, tree root invasion model and hydraulic and structural failure modules. The proposed integrated management model is suitable for capturing the whole of life performance of any infrastructure asset.

Keywords: Storm water pipe failure, Asset management, Deterioration modelling, Life cycle costing

SECM/15/155

DETERMINATION OF TENSILE STRAIN CAPACITY OF FRESH CONCRETE: A NEW TEST METHOD

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Abstract:
Measuring physical properties of fresh concrete is important to understand the behaviour of the early state of concrete. Plastic shrinkage occurs at the very early stage due to evaporation of water from the concrete surface. When concrete is restrained against plastic shrinkage, tensile strain is developed and when it exceeds the tensile strain capacity, cracks occur. This phenomenon is called as plastic shrinkage cracking. In order to assess the risk of plastic shrinkage cracking tensile strain capacity of fresh concrete should be measured. Fresh concrete means the concrete before the initial setting time which is still in a semi liquid state. The paper presents a test method developed to measure the strain distribution along a fresh concrete sample. Based on this test method tensile strain capacity of a selected mix proportion with three different types of cements, i.e., Ordinary Portland Cement, Fly ash blended and Portland Limestone Cement were determined. Results indicate that concrete with fly ash blended cement has a higher tensile strain capacity than other two cement types.

Keywords: fresh concrete, plastic shrinkage cracking, tensile strain capacity

SECM/15/156

SOME ENGINEERING ASPECTS OF ANCIENT STRUCTURES

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Abstract:
Large monumental constructions were a prominent feature in ancient Sri Lanka. Construction materials and techniques used in the past can be of significant interest to the modern engineer. The evolution of brick sizes during four ancient periods of Sri Lanka spanning from 375 B.C to 1350 A.D. was studied by using recorded data of bricks found on ancient construction sites. The calculated ratios and the relationships indicate that the length was relatively significant in the reduction of the brick sizes while breadth and thickness changed roughly in proportion to the length at a lower rate. The effect of ground condition, i.e. rock, strong soil and weak soil; and the effect of pedestals on a solid hemispherical dome type Stupa were analysed using SAP2000. It was found that a stupa, if unrestrained along its horizontal directions, could experience tension being developed at the centre when built on a weak soil. Also, when constructed on poor ground conditions a pedestal reduces the compressive stresses at the base. However, the pedestal causes higher hoop and radial tensile stresses closer to the top and bottom of the outer surface of the dome. Vaulted structures in Sri Lanka exhibit approximately similar span to wall thickness ratios, thus indicating the possibility of the design being governed by the geometry of the structure. Also the development of stresses in vaulted structures indicates that the maximum vertical stress is compressive at the base, while the maximum tensile stress is at the crown intrados.

Keywords: Brick sizes, Foundation, Hoop stresses, Pedestals, Vaulted structures

SECM/15/157

DYNAMIC RESPONSE OF RC BRIDGES DUE TO HEAVY VEHICLES

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Abstract:
As a South Asian country, Sri Lanka is having a promising development in infrastructures in the country. Amidst of them, concrete bridges that are constructed in highways and expressways have substantial effect on developing transportation sector. The performance evaluation of bridges starts with the inspection of the bridge to determine the present condition. Currently, Structural Health Monitoring (SHM) in most of the developed countries is characterized by traditional visual inspection along with referencing of old inspection reports to maintain an accurate account of the bridges condition. This paper presents evaluating method for current condition of reinforced concrete bridges by evaluating dynamic characteristics of the bridge. Accelerations of the bridge were measured by imposed in moving vehicles. For the measurements, tri-axial accelerometer was used. Analysing of the acceleration is complex due very large number of readings and acceleration values required to filter from other disturbances. Matlab program was developed to filter and analyse the acceleration readings. In addition, displacements were calculated from the acceleration waveforms to evaluate bridge stiffness for different moving loads. The effect of the loads generated by moving vehicles on the displacement of the bridge is varying with the speed of the vehicle. To simulate that in model of the structure, an appropriate method was applied. By considering both result taken from actual acceleration measurements and the model, current condition state of the bridge was evaluated.

Keywords: Structural Health Monitoring, acceleration, displacement, bridge rating

SECM/15/158

A STUDY ON MODELING OF CONFINEMENT IN RC COLUMNS

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Abstract:
To understand the confinement through transverse reinforcement in reinforced concrete (R.C.) column under axial compression, a three dimensional finite element model is developed using ANSYS software and the results are also verified with experimental results. Total eighteen specimens of having 800 mm length and different diameters (146 mm- 208 mm) were tested to obtain stress-strain variations. In present study, an unconfined stress-strain model of concrete was found to be suitable for the modeling of reinforced concrete columns. A parameter A_{tie}/S^2 (ratio of cross-sectional area of lateral tie to the square of spacing between lateral ties) was taken to check the effective confinement of concrete core in R.C. column. It can be concluded that if A_{tie}/S^2 is greater than 0.02 then confinement model of concrete proposed by Mander et al.[1] may be used and if it is less than 0.02 then concrete should be modeled as unconfined.

Keywords: finite element analysis; confinement; ductility, ANSYS.

SECM/15/159

EXPERIMENTAL STUDY ON INTEGRATED METHOD OF NSM AND EBR TECHNIQUES FOR FLEXURAL STRENGTHENING OF CONCRETE BEAMS USING CFRP

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Abstract:
This paper is based on an experimental analysis carried out to identify the effectiveness of different installation techniques of CFRP (Carbon Fibre Reinforcement) in concrete elements. Two new methods of integration of externally bonded reinforcement (EBR) and near surface mounted (NSM) methods were also experimented with the objective of increasing the flexural capacity of reinforced concrete beams by increasing the effective area of CFRP strips used. The main objective of this research paper is to identify the adaptability of existing guidelines specified for the EBR and NSM methods separately into the new installation method of integrating the two techniques of EBR and NSM.

Keywords: adhesives, externally bonded reinforcement, near surface mounted CFRP, concrete, method of integration

SECM/15/160

ACI GUIDELINES TO ASSESS THE PERFORMANCE OF CFRP-STRENGTHENED CONCRETE BEAMS WITH TRANSVERSE END U WRAPS

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Abstract:
In this comprehensive study, firstly, the theoretical model described in ACI 440 committee report to calculate the area of transverse U wraps provided for anchored CFRP-strengthened concrete beams was examined. Then, an experimental study was carried out with a total of 10 small-scale test specimens and test parameters were set to inspect the validity of the limitations given in the above theoretical model. Theoretical calculations were performed in accordance with ACI guidelines for the above test specimens as well as for the previous research studies. Finally, the constraints of applicability of the theoretical model given in ACI 440 committee report was discussed presenting new recommendations for different scenarios.

Keywords: CFRP, debonding, flexural capacity, transverse end U wraps

SECM/15/161

INVESTIGATION OF APPLICABILITY OF DIFFERENT MODELING METHODS AVAILABLE IN HEC-HMS FOR MODELING KALU RIVER UPPER CATCHMENT IN SRI LANKA

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Abstract:
Water is one of the most precious resources on earth without which human cannot survive. Studying conversion of rainfall to runoff is very widely used in water related studies. Modeling rainfall runoff process in a watershed can be done by different approaches. Lumped hydrological modeling is one such approach which measures the flow as a function of time only. This paper presents a study carried out to investigate the suitability of different combinations of baseflow methods, loss methods and transformation methods available in HEC- HMS software, a very widely used lumped hydrological model in rainfall runoff modeling.

Kalu Ganga upper catchment up to Ratnapura was area used in the study. For the development of catchment area and its boundaries SRTM DEM data were used in Arc GIS (10.2) environment. The developed catchment was exported to HEC-HMS software using HEC-GeoHMS software. Several modeling methods available in HEC-HMS for loss, transfer and baseflow processes were tested for their suitability for the selected catchment. The different models were calibrated and validated based on rainfall and runoff data for two different periods. Performance of each parameter combination was assessed based on Nash-Sutcliffe coefficient. Finally, most suitable modeling methods for the Kalu Ganga upper catchment were determined as constant loss method, Snyder unit hydrograph transformation method and constant monthly baseflow method.

Keywords: HEC- HMS, loss methods, baseflow methods, transformation methods

SECM/15/162

EMBODIED ENERGY ANALYSIS OF A PRE-CAST BUILDING SYSTEM

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Abstract:
The embodied energy of a building can represent up to 40% of life cycle energy use of residential buildings. Residential buildings in Sri Lanka serve as one third of the local construction sector. However, extraction materials which are extensively used in building construction in Sri Lanka are being limited by the environmental regulations and depletion of resources. Precast concrete products are generally chosen for achieving sustainability in buildings since they incorporate holistic design, efficient use of material and minimize the construction waste and site disturbance. This paper presents a comparative analysis of embodied energy of a conventional in-situ building system and a precast building system: a case study for two identical buildings constructed at the same location using the two building systems. The results of the analysis reveal that the embodied energy of the precast building system is 19% less than the conventional in-situ building system.

Keywords: building materials, embodied energy, expanded polystyrene, pre-cast building

SECM/15/163

CLIMATE CHANGE IMPACT PREDICTION IN UPPER MAHAWELI BASIN

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Abstract:
Upper Mahaweli basin is the origination of the main water source of Sri Lanka which is the Mahaweli River. Therefore it is a timely requirement to identify the future climate trends on the basin, to take suitable adaptation strategies. Statistical Downscaling model (SDSM) was used to predict future rainfall patterns of the study area. Observed point rainfall data of ten gauging stations within the study area and Global Climate Model (GCM) data of Hadley Centre Coupled Model, Version 3 (HadCM3) were used for model calibration and validation processes. A representative data set for the study area was generated using Thiessen polygon method from the observed rainfall data of selected gauging stations. Quality of the input data was checked prior to the model calibration. Daily rainfall was forecasted from 1961 to 2099 under A2 (high emission scenario) & B2 (low emission scenario) defined by Intergovernmental Panel on Climate Change (IPCC). Under A2 scenario the total annual rainfall, maximum annual rainfall and annual averaged daily rainfall show an increasing trends and under B2 scenario all the above mentioned parameters show decreasing trends. But the recorded decreasing trends are insignificant.

Keywords: global climate models, statistical downscaling model, emission scenarios

SECM/15/164

INVESTIGATION ON RESIDUAL CYCLIC STRENGTH CAPACITY OF CORRODED STEEL BRIDGE MEMBERS

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Abstract:
Steel bridges play a major role in road and railway infrastructures hence it directly influence on economy of any country. Traffic capacity reduction or even a temporary closure generates major inconveniences for the users and result in significant losses to the economy. Corrosion is one of the most significant causes of age related deterioration of steel girder bridges which affects their strength, long term mechanical performance, usability and durability. Numerous steel bridge structure collapses are associated with dynamic loadings like earthquakes and wind loading. Damaging vulnerability of steel structures due to dynamic excitations can be triggered with corrosion. Non availability of information and convenient methodology to determine the behavior of corroded steel members can lead to problematic situations for the civil engineers when evaluating the strength of deteriorated member.

Therefore a comprehensive study in front of serviceability and ultimate limit states is necessary to develop efficient techniques to evaluate the structural integrity and safety. This is necessary to evaluate the feasibility of those steel structures for the current usage and to figure out the retrofitting requirement of corroded members. This research proposes a simple and reliable methodology to estimate remaining yield and ultimate cyclic strength capacities by measuring only the minimum thickness of a corroded surface based on the results of many experimental coupon tests and results of nonlinear FEM analysis of many actual corroded plates with different corrosion conditions, which can be used to make rational decisions about the maintenance management plan of steel infrastructures.

Keywords: Residual strength, cyclic loading, finite element analysis, corrosion, bridge structures.

SECM/15/165

RHEOLOGICAL BEHAVIOUR OF CEMENT PASTE WITH FLY ASH IN THE FORMULATION OF SELF-COMPACTING CONCRETE (SCC)

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Abstract:
The use of Self-Compacting Concrete (SCC) is growing rapidly due to its ability to compact solely under its own weight. But, due to the unavailability of a universally approved mix design procedure, the industry uses trial and error methods to proportion mixes leading to high material and time wastage.

Unlike traditional concrete, SCC possesses a very high workability. Thus, it is worthwhile to be evaluated through a rheological point of view. But, to facilitate high workability, SCC requires a sufficient amount of paste to fill the voids and confine its aggregates. However, if the binder or the cement content is raised to achieve this purpose, it will result in many negative structural and non-structural impacts. It will not only increase the cost, but will also lead to cracks due to the increased heat of hydration. It will also harm the environment through excessive use of resources, while contributing to the emission of large amounts of carbon dioxide, a greenhouse gas. Therefore, Supplementary Cementitious Material (SCM) such as fly ash could be identified as a better supplement to overcome these problems.

This study focuses on determining the yield shear stress and plastic viscosity (Bingham constants) of paste having varying constituent proportions, by using coaxial type rheometer. Both individual and combined effect of water/cement (w/c) ratio and fly ash content on the rheological behaviour is observed and analysed to determine the optimum SCM composition for a mix for two common w/c ratios. The results for optimum material quantities could be used as a guide for initial trial mixes, minimizing the time and material wastage.

Keywords: rheology, self-compacting concrete, bingham model, coaxial concentric rheometer, fly ash

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NOVEL METHOD FOR DEVELOPING S-N CURVES FOR CORROSION FATIGUE DAMAGE ASSESSMENT OF STEEL STRUCTURES

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Abstract:
Corrosion is one of the main problems in steel structures. The combined effect of corrosion and fatigue caused by cyclic loading magnifies the damage severely reducing the fatigue life of the structure. Steel bridges in coastal and industrial zones are among the structures most vulnerable to corrosion fatigue. Up until now there have been no accurate methods introduced for assessing corrosion fatigue damage and predicting the future life of structures in a corrosive atmosphere.

In the S-N approach based fatigue damage assessment method S-N curves should include corrosion effects. If usual S-N curves that do not include corrosion effects are used, they should be modified or safety factors should be applied to account for the effects of corrosion. The present paper describes a study carried out for improving one of the existing full range S-N curve models for corrosion effects. Using adjustments to the existing S-N model a new corrosion based S-N model was proposed. Experimental results showed that the proposed S-N model can be efficiently used for assessing fatigue damage of steel structures located in corrosive atmosphere. The S-N model proposed remains a simple single formula. The only parameters necessary for the new corrosion based S-N model are the ultimate tensile strength, Vickers hardness and the high cycle fatigue strength in corrosive environment.

Keywords: corrosion fatigue, damage assessment, life evaluation, S-N curve, steel structures

SECM/15/167

BIM SOFTWARE FRAMEWORK FOR PREFABRICATED CONSTRUCTION: CASE STUDY DEMONSTRATING BIM IMPLEMENTATION ON A MODULAR HOUSE

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Abstract:
Building information modeling and prefabrication are concepts that are undergoing intense study in the construction industry. As the technology to implement BIM is commercially available, many industries have started to use BIM in construction related projects. However, BIM implementation can vary significantly according to the nature of the project. Therefore, development of a BIM software framework for a particular industry to meet its requirements is the most efficient way to use Building Information Modeling. This paper will present a BIM software framework developed for prefabricated construction industry and will demonstrate the use of the framework during the design stage of a modular pre-fab house.

Keywords: Building Information Modeling, Prefabrication, BIM Software Framework, Construction

SECM/15/168

STRUCTURAL FEASIBILITY OF VERY-HIGH STRENGTH CONCRETE (100 – 150 MPA) FOR TALL BUILDINGS

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Abstract:
Use of high strength concrete, HSC (50– 100 MPa) and very high strength concrete, VHSC (100 - 150 MPa) concrete is considered as an economical alternative to normal strength concrete, NSC due to higher stiffness, strength, durability and low in long term deformation. Understanding the mechanical behaviour and properties of VHSC, including ductility is essential to evaluate suitability for structural applications. Basic mechanical properties, such as compressive strength, elastic modulus, tensile strength and ductility were evaluated using standard methods for VHSC. Ductility is a very important material property in structural engineering due to the ability to give a pre warning before failure of the structure or undergo large deformation while sustaining load carrying capacity and dissipate energy in hysteresis cycles. However, very-high strength concrete (100 – 150 MPa) is considered as a brittle material and it restrains the use of VHSC concrete in structural applications. In this paper, analytical full-range moment curvature relation is used with material properties from experiment results and appropriate stress-strain behaviour of constitutive material in order to evaluate ductile capacity of VHSC concrete columns including possible failure mechanism such as spalling; and fracture of longitudinal and lateral steel. The studies conclude that, VHSC can be produced economically using suitable aggregates, silica fumes and modern high-water reducing superplasticizers. VHSC have desirable structural properties as very high strengths, high elastic modulus and tensile strengths. Finally it is concluded through a ductility evaluation approach that VHSC columns can be used in limited ductile structures located in non-seismic and low seismic areas.

Keywords: Very high strength concrete, ductility, Columns, tall buildings

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FIRE SPALLING OF CONCRETE MEMBERS

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Abstract:
Thermal instability "spalling" occurs when concrete is exposed to fire. This phenomenon, which happens early after a fire starts (about twenty minutes), is one of the most detrimental effects causing damage to concrete members. It can trigger an immediate degradation of concrete, exposure of steel reinforcements to high temperatures and then eventually can cause failure of the concrete members during or after a fire by decreasing the residual mechanical properties and durability of the structure. In spite of many experimental and numerical studies, the real mechanism of spalling is still not well established. Hence, more comprehensive studies on simulating the behaviour of concrete members exposed to fire to investigate the real physics involved and the affecting factors on this phenomenon are currently lacking. The current study at University of Melbourne is attempted to fill this gap. The lack of understanding of the origin of fire spalling is mainly due to the erratic nature of this phenomenon and inhomogeneity of the concrete structures. To establish a more clear view of the phenomenon further investigation is needed. This paper reports the latest findings on fire spalling behaviour of concrete members and shows the deficiencies of the current experimental work and knowledge.

Keywords: fire, spalling, concrete, influencing factors

SECM/15/170

FATIGUE LIFE PREDICTION OF STEEL BRIDGESWITH HIGH AMPLITUDE LOADINGS

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Abstract:
This paper presents a new fatigue model to predict life of steel bridges considering the effect of high amplitude loading. It consists of a modified strain-life curve and a new strain based damage index. Modified strain-life curve consists of Coffin-Manson relation in low cycle fatigue region and a new strain-life curve in high cycle fatigue region. The damage variable is based on a modified von Mises equivalent strain to account for the effects of loading non-proportionality and strain path orientation in multiaxial stress state. The proposed model was verified with experimental test results of two materials available on the literature. Then, it was illustrated with an old riveted wrought iron railway bridge. The obtained results verify the effectiveness of the proposed model over commonly used Miner's rule based life prediction of steel bridges.

Keywords: High cycle fatigue, low cycle fatigue, steel bridges, life prediction, high amplitude loading.

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STRATEGIES FOR PLANNING MOULD FREE AIR CONDITIONED BUILDINGS IN TROPICAL CLIMATES

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Abstract:
Buildings constructed in tropical climatic conditions must be designed to have a very low carbon foot print that will need the buildings to be used as free running while ensuring adequate thermal comfort with passive means. However, there could be certain instances when the use of active means of thermal comfort like air conditioning will be inevitable due to special requirements. Hospital buildings or buildings with special equipment would need lower indoor temperature like 15 – 18 ^{o}C compared to the ambient temperature in tropical climates. Thus, the growth of mould on the building elements such as walls and floors of the surrounding areas will be inevitable unless special planning provisions have been used with strategically placed buffer zones that will have normal air conditioning which maintains indoors with relatively lower levels of moisture content. Mould created on various building elements can produce spores, air-borne particles and gases which are harmful to the humans and built environments. In order to identify the magnitude and the causes for mould growth, a comprehensive research was carried out with a case study in a hospital building planned without attention to much detail and hence led to a severe growth of mould, where several concerns were raised by the occupants of the building, related to sick building syndrome. This will shed light on special planning precautions that must be taken by the architects and engineers who plan buildings with specially air conditioned spaces in large buildings located in countries with tropical climatic conditions.

Keywords: mould growth, condensation, air conditioned buildings, air quality

SECM/15/172

WIND DESIGN OF SLENDER TALL BUILDINGS: CFD APPROACH

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Abstract:
Urbanization has led to the uprising of such buildings in densely populated areas where land availability and prices are a concern in such areas. Where such concerns exist the land must be fully exploited and thus constructions of tall buildings are always found as a solution in such areas. Wind behaviour is a key designing parameter for such building and need to be assessed accurately in the preliminary and secondary design stages. As most of the existing design codes have their own limitations in providing necessary guidelines for the wind designing, such as height limits of the buildings, the existing practice is to conduct wind tunnel tests to determine the wind induced loads on the buildings. However, the cost of the wind tunnel test is comparatively high and conducting wind tunnel tests at preliminary design stage is uneconomical. The rapid growth of Computation Fluid Dynamic (CFD) technique over the last few decades enables Engineers to simulate the wind behaviour around moving objects such as aeroplanes and automobiles. Therefore use of such methodology to predict wind loads on the buildings, especially at the preliminary design stages could be beneficial. This paper discusses a preliminary investigation that carried out on a non-typical 350m tall slender building using CFD approach.

Keywords: wind loads, tall buildings, computational fluid dynamics

SECM/15/173

PHYSICO-CHEMICAL CHARACTERISTIC OF A PETROLEUM CONTAMINATED SOIL FROM THE SPILL SITE OF JAFFNA DISTRICT.

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Abstract:
Contamination of soil with petroleum products is among the most common sources of pollution in an industrialized world. This poses severe threats to the local communities and the ecosystem. Consequences of soil contaminations by petroleum products are multi-dimensional and thus their assessment has remained major problem. The presence of total organic carbon (TOC), heavy metals, electrical conductivity (EC) and pH were determined from petroleum contaminated soil samples from the spilled location of power plant premises of Chunnakam, Jaffna district. Three spilled locations have been identified and samples were collected from each location for this study. Control samples were collected from the uncontaminated location from the area same as the geology of the affected area. Results revealed that the heavy metal content of lead and nickel were higher than those of the control site and the recommended permissible limit. Evidence of severe hydrocarbon contamination was confirmed by presence of elevated level total organic carbon in the contaminated soil. Other analyzed metals including ferrous and manganese and physical parameters such as electrical conductivity and pH in the impacted zone have not shown any significant differences, while compared to the control samples.

Keywords: heavy metals, total organic carbon, oil spills, soil contamination

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PERFORMANCE OF SAND CEMENT BLOCK PRODUCED WITH PARTIAL REPLACEMENT OF CEMENT BY RICE HUSK ASH

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Abstract:
The sand cement blocks are cement composites and have been widely used in many countries including Sri Lanka. Rice husk ash (RHA) is a waste material with pozzolanic properties. The use of RHA as a substitute of cement is a sustainable application which solves the problem of its disposal by minimizing the environmental pollution. This paper discusses on the performance of a cellular sand cement block containing rice husk ash through an experimental investigation. The burning temperature of the RHA obtained from power plant is 650^{o}C. Ordinary Portland Cement (OPC) was partially replaced with RHA having different fineness at 5%, 10% and 15% replacement levels to produce sand cement blocks. Particle size of the finer RHA was less than 75 µm. Compressive strengthincreased upto the 10% cement replacement level only with finer RHA. Replacement percentage beyond the 10% lead to decrease the compressive strength of sand cement block. However, cement replacement with coarser RHA decreased the compressive strength at all the replacement percentages. The density of sand cement block decreasedas RHA content increased. Moreover, higher water absorption capacity was observed at higher RHA content.

Keywords: Cement, Compressive strength, Rice husk ash, Sand cement block

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BEHAVIOUR OF CONCRETE PRODUCED WITH CEMENT AND RICE HUSK ASH

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Abstract:
Disposal of rice husk and its ash has been identified as a major problem in areas where rice production is abundance. Cement is an expensive material which plays a major role in the construction industry. This study shows the utilization of Rice Husk Ash (RHA) in concrete by conducting the laboratory experiments. Replacement of cement with RHA enhances both compressive and tensile properties of concrete. For this study, RHA was obtained from Bio-Energy power plant located in Ampara, Sri Lanka. As received RHA was sieved in order to prepare two types of samples with different particle sizes. Enhanced performances of Ordinary Portland Cement (OPC) can be achieved with 10% replacement of OPC by RHA regardless of particle sizes. Moreover, the adverse environmental impacts associated with RHA can also be reduced by utilizing the RHA in cementitious systems.

Keywords: compressive strength, concrete, rice husk ash, tensile strength

SECM/15/176

DOMINO EFFECT OF RIVER TRAINING IN LARGE SAND-BED BRAIDING RIVERS

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Abstract:
Large sand-bed braiding rivers such as the Brahmaputra River form an enormous challenge to understand and to control. For efficient and sustainable management of these rivers, it is vital that we can predict the effects of river training works on the channel pattern and dynamics. In this study we used a computer model to simulate the dynamics of bars, islands and channel branches in a large sand-bed braiding river. We applied river training works in it to evaluate the nearby effects and the far-away effects. The results showed that a single river training work like bank protection or a groin can significantly affect the locations of bars, islands and channel branches far downstream. The downstream propagation of the effect of a river training work is a domino effect by means of bifurcation instability and bar shape adjustment. It means that a training work can adjust navigation channels, bank erosion and flooding over many kilometres downstream of the training work. Thus, a training work in a large sand-bed braiding river not only has local effects on the flow and river bed, but can also have major economic and social impacts. This is both a sign to be very careful with river training in these rivers, and a great opportunity to change a long river reach by a single, relatively cheap river training work.

Keywords: Rivers, discharge, river pattern, modelling, sand transport

SECM/15/177

PROBABILISTIC PERFORMANCE-BASED EARTHQUAKE ENGINEERING: A REVIEW

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Abstract:
The next generation seismic design and assessment procedures for buildings within the performance-based framework are a radical departure from traditional seismic design practice and performance assessment. The uncertainty and randomness in the building performance and seismic hazard will be captured and quantified in each steps in design and assessment procedure, finally the performance will be measured in terms of direct and indirect economic losses and casualties. The quantification and propagation of uncertainty in every step in the procedure requires robust probabilistic methods that have been developed over the last two decades. This paper summarises the research undertaken to develop the probabilistic performance-based seismic design and assessment procedures for buildings. The analysis methods, fragility functions and seismic hazard qualification, which are key elements in procedures, are defined and discussed.

Keywords: building, intensity measure, incremental dynamic analysis, uncertainty

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STRUCTURAL FEASIBILITY OF A PRE-CAST BUILDING SYSTEM

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Abstract:
This paper is based on a case study on a model house, which is to be built with slabs, beams and columns, constructed using pre stressed concrete and wall panels constructed out of Expanded Polystyrene. The proposed system is a solution to the fast growing issue of increased demand for housing and buildings and will contribute towards sustainable development with its cost effectiveness and optimized usage of resources. The beams, slabs and columns are pre-stressed in the form of pre-tensioning and Dowell bars are used at the beam-column junctions. As for the wall panels, a mix design would be carried out to identify the optimum cement, fly ash, sand, Expanded Polystyrene proportions. Seismic design has become an integral component in modern day engineering and hence, its implications on a pre-stressed concrete structure and a method to evaluate the feasibility of the proposed system in terms of its ability to withstand the effect due to earthquakes are proposed in the paper.

Keywords: connections, expanded polystyrene, pre-stressed concrete, seismic design