ICSBE 2023

The 14th International Conference on

Sustainable Built Environment -2023

The Kandy Conference

BOOK OF ABSTRACTS

Editors
Prof. Ranjith Dissanayake | Dr. Pradeep Gajanayake

Abstract Book of the 14th International Conference on Sustainable Built Environment – (ICSBE) 2023

Vision

To drive innovative research for tomorrow's development

Mission

To meet colleagues, experts, and friends in the field and to exchange ideas and those about research development work, concepts and practical ideas in structural, Construction and management

ISSN 3021-6966

Published by:
Graduate AssociateProfessionals (Pvt) Ltd
Science Tower 120/10A, Vidya Mawatha, Colombo 07

PREFACE

It is with great pleasure that we present the proceedings of the 14th International Conference on Sustainable Built Environment (ICSBE) 2023. This is the fourteenth consecutively organized conference following a series of international conferences since 2010, keeping its tradition of adhering to engineering excellence. Taking a step forward from the last thirteen events, the coverage of specialty areas in this conference has been diversified. This book contains the abstracts of research work from many different sub-specialties. We expect that all these abstracts will be presented at parallel sessions from 16th to 17th December 2023. We would like to express our appreciation to all keynote speakers for their valuable contributions to the development of a sustainable world. We are also very grateful to the authors for contributing research papers of high quality. The abstracts in this proceeding book have been reviewed by a panel of academic and professional experts who have vast expertise in their respective fields. The enormous work carried out by these reviewers is gratefully appreciated as well. We are also pleased to acknowledge the advice and assistance provided by the members of the local and international advisory committee and members of the co-chairs committee along with many others who volunteered to assist to make this very significant event a success. Furthermore, we acknowledge the financial sponsorship provided by many organizations that have been extremely supportive of the success of this international conference. It is the earnest wish of the editors that this proceeding book would be used by the research community and practicing engineers/scientists who are directly or indirectly involved in studies related to sustainable built environments.

Editors
Prof. Ranjith Dissanayake
Dr. Pradeep Gajanayake

The 14th International Conference on Sustainable Built Environment (ICSBE) 2023
15th to 17th December 2023, Kandy, Sri Lanka

A MESSAGE FROM THE VICE-CHANCELLOR, UNIVERSITY OF PERADENIYA

I am delighted to share a message marking the 14th International Conference on Sustainable Built Environment (ICSBE) 2023.

I commend the Conference for maintaining consistently high academic standards throughout its history. Over the past 14 years, it has provided an exceptional platform for engineers, scientists, and researchers to showcase advancements in research and development, as well as the practical application of new tools and technologies.

In line with its established legacy, the Conference is expanding its focus by embracing new areas, particularly technical and industrial collaborations. The technical sessions of the Conference, centered around the theme "Building Sustainable Nations," directly align with the university's current developmental plans. The University has initiated an ambitious plan aiming for significant advancements in all aspects by its centenary year in 2042. Central to these developmental plans is our dedication to sustainability, aligning with the specific goals outlined by the United Nations. I am confident that participants from the university will utilize the insights from the conference to refine and adapt our developmental strategies accordingly.

I extend my heartfelt congratulations to the organizing committee of ICSBE – 2023 and convey my sincere wishes for a successful, impactful, and inspiring conference.

Thank you.

Prof. M. D. Lamawansa
Vice Chancellor
University of Peradeniya

MESSAGE FROM THE CONFERENCE CO-CHAIRS

It is a pleasure for us to welcome all the participants to the 14th International Conference on Sustainable Built Environment (ICSBE) 2023 in Kandy, Sri Lanka. We, the co-chairs would gratefully like to mention the previous successful conference, which was held for thirteen consecutive years in Kandy, Sri Lanka. The theme selected for the conference Sustainable Built Environment is extremely relevant to today's world. With the vision of promoting innovative and sustainable 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 the different sub-topics in the sustainable built environment: such as sustainable construction, sustainable infrastructure development & planning, urban green infrastructure & planning, sustainable cities and villages, waste & wastewater management for enhanced sustainability, advanced water & wastewater technology, rainwater harvesting, water conservation, solar energy, bio-energy, wind, and hydro-power energy, alternative clean energy, green advanced computations & communication, green energy economics, policy, financing & business practice, sustainable materials, material flows & industrial ecology, high-performance concrete, remove, recycle, repair of materials, building automation, indoor environmental quality, indoor plants, impacts of climate change, climate change & reducing greenhouse emissions, carbon footprint, impacts of sustainable bio-fuel, social impact & human behavior, climate risk management & mitigation, global climate model and landscaping. The best-selected papers will be published in Springer Nature as lecture notes in civil engineering. Other full papers (which are presented at the conference) are published as conference proceedings with ISSN number. The host city of the conference, Kandy, is a world heritage city famous for its unique architecture, culture, nature, 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, sponsors, and many others who volunteered to assist to make this very significant event a success.

Prof. Ranjith Dissanayke
Prof. Priyan Mendis
Prof. Chintha Jayasinghe
Prof. Sudhira De Silva
Prof. Upul Attanayake
Prof. Chaminda Konthesingha
Prof. D. A. R. Dolage
Dr. Ajith Thambo
Dr. Balasubramaniam Janarathnan
Eng. Shiromal Fernando

The 14th International Conference on Sustainable Built Environment (ICSBE) 2023

MESSAGE FROM THE CHIEF GUEST

Dear friends and colleagues,

It is an honor and a privilege for me to pen this brief message, as the Chief Guest, on the occasion of the 14th International Conference of The Sustainable Built Environment, although this year's theme is much more - on the multi-disciplinarity of sustainability.

First, I wish to congratulate the organizing committee ably led by Professor Ranjith Dissanayake for `sustaining` this `Kandy Conference` for over 14 years, which is no mean task by any measure. As an academic who has worked in all five continents as a clinician, teacher, and an executive Dean, I am well aware of the energy and the unremitting tenacity required for maintaining the vigor of such a conference series.

The theme of this year's conference is multi-disciplinarity of sustainable development, and is built on the 17 sustainable Millennium Development Goals (SDGs) set in 2000, that were formally adopted by all 193 member states of the UN in September 2015, aiming at ending extreme poverty, protecting the planet and ensuring prosperity for all by 2030 (UN, 2015). The SDGs expanded the agenda to include issues such as climate change, sustainable consumption, *but also quality education* requiring all countries to take action including those with high levels of development.

The goal of education for sustainable development (UN, 2015, p. 21) entails that ` *that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, education for sustainable development and sustainable lifestyles, human rights, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and its contribution to sustainable development.*

I am proud to say as a Sri Lankan we have embraced this ethos of quality education for a very long period and what's more with virtually free provision of quality education to all, despite being a developing nation, still facing many hurdles. This is exemplified by our 17 universities and the global diaspora of graduates in varying professions. Incidentally I hope many of you who are here today will have the opportunity to visit one of the most beautiful campuses in the world, a few miles away – our University.
of Peradeniya Campus, built in 1942, along the lines of Cambridge University, UK, and adorned by the undulating Mahaweli river.

Although Sir Lanka and many other jurisdictions have some way to go before achieving the foregoing erudite goals `of education for sustainable development` conferences such as these help nurture the ethos and popularise these goals, particularly when held under the auspices of a tertiary education institute.

In closing this short message, I wish you all a wonderful and a productive conference with many networking opportunities, whilst at the same time enjoying the breath-taking vistas and cuisine Sri Lanka has to offer.

Sincerely,

Lakshman Samaranayake
Professor Emeritus and Immediate-Past Dean, Faculty of Dentistry
University of Hong Kong, Hong Kong

Table of Contents

TALL BUILDING

ICSBE 2023-402

PREDICTING TRANSIENT ALONG WIND PRESSURE OVER A TALL BUILDING USING MACHINE LEARNING

Pasindu Maddage[1], Kasun Wijesooriya [1], Damith Mohotti [1*]

[1]School of Engineering and Technology, The University of New South Wales, Canberra, ACT 2600, Australia..

**Correspondence E-mail: d.mohotti@unsw.edu.au, TP: +61251145160*

Abstract: Traditional methods for modelling transient wind pressure over buildings, such as wind tunnel testing, full-scale experiments, and computational fluid dynamics (CFD), are resource-intensive and require significant expertise and time. In this study, we propose using machine learning to model transient wind pressure over a building. Subsequently, wind tunnel tests and numerical modelling will be conducted to cover a wider range of aspect ratios. In addition, we would utilize explainable artificial intelligence to explain the underlying reasoning of the machine learning models. Finally, we aim to develop a surrogate model and introduce a user interface for predicting wind pressure on buildings with various shapes. The interface is intended to be used by civil engineering community for wind engineering designs as a fast and reliable way to model wind pressure.

Keywords: Machine learning, Transient wind, Tall buildings, Artificial intelligence

ICSBE 2023-176

EVALUATION OF EARTHQUAKE DESIGN RESPONSE SPECTRA FOR SRI LANKA CONSIDERING SHORT PERIOD EFFECTS

H.A.D.S. Buddika*, N.S. Peiris, B.R.D. Peiris

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

**E-mail: samithbuddika@gmail.com, TP: +94772171984*

Abstract: Sri Lanka lacks a comprehensive earthquake design guideline for seismic analysis and design of structures. Hence, engineers are forced to use foreign earthquake design codes for structural designing under seismic loads. This study focuses on the development of response spectra for Sri Lanka, considering the effects of short period ground motions. Initially, the available earthquake design response spectra proposed in the literature were evaluated. Two categories of ground motions were selected: short periods with magnitudes less than 5.5 for soil type A, and short periods with magnitudes greater than 5.5 for soil type A. Soil classification was done based on the Eurocode 8 guidelines, and these ground motions were chosen from the PEER database. For short period ground motions with magnitudes less than 5.5 for soil type A, it was observed that the mean plus standard deviation closely followed the response spectrum specified in Eurocode 8 for magnitudes less than 5.5 and soil type A. Moreover, the mean response spectrum was found to be well below the standard response spectra. For short period ground motions with magnitudes greater than 5.5, the mean spectrum closely followed the response spectrum proposed by Venkatesian et al. (2017), while the mean plus standard deviation closely matched the response spectrum presented by Seneviaratne et al. (2020). Furthermore, to develop response spectra for other soil classes, the modification factors proposed in Eurocode 8 are recommended.

Keywords: Seismic; Ground Motions; Short period; Response spectrum

ICSBE 2023-271

IDENTIFICATION OF NATURAL FREQUENCY AND DAMPING RATIO OF TALL BUILDINGS IN SRI LANKA USING AMBIENT WIND VIBRATION DATA

H.A.D. Samith Buddika[1*], U.G.K. Prabodya[1], T.A. Madusanga[1]

[1]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Kandy, Sri Lanka

**Correspondence E-mail: samithbuddika@eng.pdn.ac.lk, TP: +94772171984*

Abstract: In recent years, the demand for tall buildings in Sri Lanka has rapidly increased. When evaluating the wind design aspects of tall buildings, it becomes evident that the natural frequency and damping ratio assume utmost importance. These two factors play a pivotal role in accurately estimating the design wind load and forecasting wind-induced responses for such structures. Nonetheless, within the Sri Lankan context, a conspicuous gap exists as there is an absence of empirical formulations tailored for the estimation of these dynamic parameters essential for wind engineering design. Consequently, there is a compelling need to establish a comprehensive database comprising identified natural frequencies and damping ratios specific to tall buildings in Sri Lanka. These findings will serve as the basis for proposing empirical equations to estimate the fundamental natural frequencies and damping ratios. In this study, the natural frequency and damping ratio of selected existing tall buildings in Sri Lanka, are estimated using ambient wind vibration data and operational modal analysis techniques. The random decrement technique (RDT) was used to obtain free vibration response from ambient vibration data. Then, Fast Fourier Transformation (FFT) and Continuous Wavelet Transformation (CWT) were used to estimate the natural frequency and damping ratio. CWT is widely used to identify the dynamic properties of tall buildings and can provide reliable results compared to other methods. When the results were compared to the values calculated using design codes, it was observed that the damping ratios tended to be higher than anticipated, while the natural frequencies were found to align quite well with the calculated values from the literature. Further identification of the natural frequency and damping ratio of existing tall buildings is recommended to develop a database of the dynamic properties of tall buildings in Sri Lanka.

Keywords: Continuous Wavelet Transformation; Damping ratio; Natural frequency; Tall buildings

ICSBE 2023-282

NUMERICAL STUDY ON EXTERNAL PRESSURE VARIATION OF TALL-BUILDINGS DUE TO INTERFERING EFFECTS

E. M. R. Ekanayake[1*], H. M. A. I. Herath[1], J. A. S. C. Jayasinghe[1] and A. J. Dammika[1]

[1]Faculty of Engineering, University of Peradeniya, Sri Lanka.

** E-mail: e16095@eng.pdn.ac.lk, TP: +94778638848*

Abstract: The role of wind is pivotal in the planning and construction of tall buildings. As a building's height increases, the influence of wind becomes more pronounced, amplifying the significance of both stability and safety. One significant consequence that demands attention is the "interfering effect". This effect, a phenomenon within wind engineering, arises when an interfering structure influences the wind load on a principal building. In the past, investigations into the external pressure variation of the principal building due to interfering effects focused on 2D or 3D simulations, often considering only a limited subset of parameters encompassing shape, height, and angle. Thus, the present study attempts to comprehensively examine the external pressure variation of the principal building due to interfering effects qualitatively and quantitatively. It accomplishes this by carefully analyzing the influence as it spreads from the interfering structure to a specifically chosen principal building, which has a square shape. It varies the height of the interfering building while adopting diverse shapes: square, circular, cross, and triangular, with varying orientations. The basis of this analysis rests upon 3D Computational Fluid Dynamics (CFD) modelling, facilitated by the Midas NFX commercial CFD software. In light of the outcomes deduced from pressure deviations, it becomes imperative to factor in a safety margin for interfering effects when designing the cladding of urban building structures. The results from pressure fluctuation analysis underscore the criticality of devising cladding system connections that can effectively withstand both compression and tension forces. In summary, for the windward face, the maximum deviation of 174.56% occurs when a circular shape is positioned at a 90-degree angle and a height of 175 meters. Conversely, for the leeward face, the maximum deviation of -107.84% is observed when a triangular shape is placed at a 90-degree angle and a height of 175 meters. The implications of this study's findings are far-reaching, particularly concerning the safety of building structures amid densely developed urban landscapes. As the urban landscape evolves, these insights will serve as a cornerstone for ensuring the enduring safety of high-rise structures.

Keywords: CFD simulations; Interfering effect; Tall-buildings; Turbulence model; Wind response

ICSBE 2023-295

COMPARATIVE STUDY OF WIND LOADING COMBINATIONS FOR TALL BUILDINGS INCLUDING TORSION: A CFD APPROACH

B. Kiriparan[1*], J. A. S. C. Jayasinghe[1], U. I. Dissanayake[1], W. J. B. S. Fernando[2]

[1]Faculty of Engineering, University of Peradeniya, Sri Lanka

[2]Civil & Structural Engineering Consultants (Pvt) Ltd, Sri Lanka

** Correspondence E-mail: kiriparan@gmail.com , TP: +94775584619*

Abstract: In the wind analysis of tall buildings considering the appropriate proportion of rectilinear loadings from both orthogonal principal axes along with the torsional moment is an important factor as it will highly influence the internal forces developed in the lateral load resistance system. Although different recommendations were introduced in wind design standards in the recent past for the combination of along wind, across wind and torsional wind loads for the analysis of tall buildings significant inconsistences were found. Further, only a limited number of research works were carried out regarding the combination of these wind loading components. This study employed a finite volume based numerical analysis using Large Eddy Simulation (LES) to determine the suitable wind loading combinations for a standard tall building (CAARC) of which wind tunnel test results are available for the validation of numerical predictions. In this study, the wind loading in both principal axis of the building and torsional moments were obtained from a validated Computational Fluid Dynamics (CFD) simulation for wind directions varying from 0 to 90 degrees. Based on the numerical results suitable critical wind loading combinations were identified. The combination factors obtained from this study were compared with three wind design standards namely AIJ: 2015, AS/NZS: 2021 and CNS: 2012. The comparison shows that the combination factors derived for the selected building reasonably match with the recently introduced load combination provisions of AIJ: 2015 and AS/NZS: 2021. However, the combination factors proposed by CNS: 2012 are found to be underestimating the wind loading effect.

Keywords: Computational Fluid Dynamics (CFD); Large Eddy Simulation (LES); Tall buildings; Torsion; Wind load combinations

CONCRETE TECHNOLOGY AND HIGH-PERFORMANCE CONCRETE

ICSBE 2023-10

IMPROVING MIXED CONSTRUCTION AND DEMOLITION WASTE USED AS FINE AGGREGATES IN CONCRETE PRODUCTION BY PHYSICAL PRE-TREATMENT

R. N. Udarika[1,2]*, C.K. Pathirana [1]

[1]*Faculty of Engineering, University of Peradeniya, Peradeniya, Sri Lanka.*

[2] *Graduate School of Science and Engineering, Saitama University, Sakura Ward, Saitama, 338-8570, Japan.*

**Correspondence E-mail: nipuni.ranasinghe@yahoo.com, TP: +81 080 6021 6440*

Abstract: Finding sustainable substitutes for natural sand in concrete is an urgent task for the construction industry. Sri Lanka must look for environmentally friendly alternatives for river sand. At the same time, the reuse and recycling of construction and demolition (C&D) waste has become a major concern, as these wastes threaten the environment and human health. Here we used recycled fine aggregates (RFA) sourced from mixed C&D waste as a substitute for fine aggregates in concrete. High water absorption of RFA, primarily caused by old cement mortar, reduces concrete workability, while the smaller size fractions result in higher mortar contents. However, the properties of RFA can be improved through simple physical pre-treatment procedures, including reduction of attached mortar content and pre-soaking. The physical properties of treated and untreated RFA were found to compare favourably with natural sand. Subsequently, the sand was replaced with treated or untreated RFA at varying intervals from 10% to 60% by weight, while 0% served as control. The properties of wet and hardened concrete, M30, produced at constant slump, were evaluated. Flexural and splitting tensile strength were not significantly affected. However, the compressive strength decreased with an increase in the proportion of RFA but less so with treated RFA. The maximal viable replacement percentage was about 30% for the untreated samples but could be extended to 50% for treated RFA. We conclude that mixed RFA can be used as supplementary fine aggregate and physical pre-treatment is efficient in improving ready mix and can be employed on-site because it is a very simple procedure.

Keywords: Construction and Demolition Waste; Recycled Fine Aggregates; Recycling; Pre-treatment

ICSBE 2023-72

FUNCTIONAL EVALUATION OF IDENTIFIED RURAL CONCRETE ROADS IN SRI LANKA - A CASE STUDY

K. P. Arandara[1], S. T. Priyadarshana[1], G. N. Pranavithana[1], R. B. Mallick[2], R. Dissanayake[3]

[1]Department of Civil Engineering, Open University of Sri Lanka

[2]Indian Institute of Technology, Delhi, India

[3]Department of Civil Engineering, University of Peradeniya, Sri Lanka

[*]Correspondence E-mail: kokila@leanandgreensolutions.com, TP: +94773521929

Abstract: Concrete Road is a familiar and popular type of roads among the rural community in Sri Lanka. This paper delivers a functional evaluation of methodically identified rural concrete roads based on a case study carried out in Sri Lanka very recently. It addresses timely quarries lined up due to a lack of post-construction studies related to seasoned-concrete roads in rural areas of the island. The authors present the findings of the qualitative assessment of physical conditions in terms of the level of service provided to road users, such as smoothness, structural dis- tress including cracking, structural adequacy, and surface friction. Also, the observations made on the horizontal levels across the carriageway, eroded or deteriorated spots on the roads, performance of construction/expansion joints, water accumulation, surface weaknesses, and side thickness of the identified roads are illustrated in the paper. The study concludes that the durability aspects and the performances of the identified roads hardly meet the specified specifications, standards, and particularly the expectations and satisfactory level of the users and rural community. Finally, the paper delivers some recommendations that could assure the quality of the future rural concrete roads.

Keywords: Rural Roads; Concrete Roads; Functional Evaluation; Qualitative Assessment; Focused Observations; Field Investigations

ICSBE 2023-145

EFFECTS OF POROSITY AND DISTRESSES IN CONCRETE ON ULTRASONIC PULSE VELOCITY READINGS

M.Mayooran[1], J.C.P.H.Gamage [1], E.R.K.Chandrathilaka [1]

[1]Department of Civil Engineering,
University of Moratuwa, Morattuwa
**Correspondence E-mail: mayoo1998@gmail.com, TP: +94771380833*

Abstract: Distresses in concrete can have effects on Ultrasonic pulse velocity (UPV) readings. Hence, it is important to identify the level of deviation between this non-destructive test reading from destructive testing. In addition, the age of concrete and blended cements in concrete may also affect on UPV measurements. In this regards, three parameters were selected as variable in this test program: concrete age, type of mix and discontinuities such as voids and cracks. UPV values notably increase as concrete ages. Equations correlating concrete strength and UPV values were obtained from literature, were compared, and the applicability of these equations were analysed for early age concrete. Processed Sugarcane bagasse ash (SCBA) inclusion leads to higher pulse velocity values, especially in 20% blends, due to pozzolanic properties promoting additional chemical reactions and improved concrete compactness. 10% and 15% SCBA blends show smoother transitions in pulse velocity, indicating reduced heterogeneity. For 10% and 15% SCBA blended concrete, equations selected from literature offer accurate UPV strength estimations with minimal deviations from concrete cube test results. However, UPV strength evaluation method is not suitable for 20% SCBA blends, as it exhibits significant deviations. Presence of voids and cracks causes a noticeable drop in UPV values. UPV testing effectively identifies damage locations and quantifies crack severity. In conclusion, UPV testing is a valuable non-destructive evaluation technique for assessing concrete properties and detecting damage. It correlates UPV values with concrete age, evaluates concrete strength in SCBA blended mixes, and identifies cracks. UPV testing enhances understanding and assessment of concrete structures.

Keywords: Concrete properties; Non-destructive testing (NDT); Destructive Testing; Ultrasonic Pulse Velocity (UPV); Reliability of UPV

ICSBE 2023-234

DEVELOPMENT OF LIGHTWEIGHT AGGREGATE CONCRETE WITH RECYCLED HDPE PLASTIC PALLETS

T.D.B. Nawarathna[1*], K.M.C. Konthesingha [1], S.M.A. Nanayakkara [2], H.M.S.C. Rathnasiri [1], I.R. Upasiri [1], W.P.H.P. Weerasinghe [1], P.M.W.P. Kumara [1], A. Branavan [1]

[1] Department of Civil Engineering, University of Sri Jayawardenepura, Colombo 10250, Sri Lanka

[2] Department of Civil Engineering, University of Moratuwa, Moratuwa, Western Province, Sri Lanka

**Correspondence E-mail: tharindunawarathna2023@gmail.com, TP: +94752650816*

Abstract: The production of lightweight concrete has gained significant traction within the construction industry. Previous studies have focused on advancing Lightweight Aggregate Concrete (LAC) through innovative lightweight components. Recent research endeavours have been dedicated to the synthesis of lightweight concrete by using recycled plastic waste as a key ingredient. Air-cooled, melted plastics have been substituted as coarse aggregates, while cleaned, shredded plastics have been used as flaky particles. This novel approach has tested High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), Polypropylene (PP), and Polyethylene Terephthalate (PET), which are subjected to purification, shredding, extrusion, and separation. These recycled plastics have replaced traditional aggregates in concrete at various proportions. However, the use of well-shaped recycled plastic pallets as lightweight aggregates for concrete has not been explored. This study focused on development of lightweight aggregate concrete by replacing recycled spherical HDPE plastic pallets as coarse aggregate and/or fine aggregate. Coarse and fine aggregates have been replaced in three different proportions (25%, 50%, and 75%) with recycled HDPE plastic pallets, and different concrete mixes and tests are done for workability, dry density, and compressive strength. As per the findings of the study, three distinct concrete compositions attained dry densities falling within the lightweight range, with the lowest obtained dry density of 1348 kg/m^3. Furthermore, this particular concrete mix exhibited a compressive strength of 7.3 MPa after a curing period of 28 days. It is observed that the dry density of all the developed lightweight aggregate concrete mixes were in the range of 1348–2265 kg/m^3. With the achieved dry density and compressive strength metrics, it can be ascertained that this specific concrete mix is adequate for the preparation of lightweight, non-structural wall-like partition walls.

Keywords: Recycled HDPE pallets; Lightweight aggregate; Lightweight concrete; Compressive strength; Dry density

SUSTAINABLE CONSTRUCTION AND GREEN BUILDING TECHNIQUES

HIDDEN ASPECTS OF PUBLIC OPEN SPACES WHEN MAKING CITIES SUSTAINABLE

R.R.J.C Jayakpody[1*]

[1]University of Manchester, Humanities Bridgeford Street Building,
Oxford Road, Manchester, M13 9PL, United Kingdom .
**Correspondence E-mail: chathu.jayakody@manchester.ac.uk, TP: +447909143002*

Abstract: It is known that public spaces can bring life breath to the cities by providing recreational opportunities, settings for special event, walking paths and improve mental and physical health of the city dwellers. Public spaces are one of the main modes to improve the social cohesion, interaction and celebrate the cultural diversity. Apart from this socio-cultural perspective, public open spaces also can bring many economic benefits with the increased land and housing prices in and around. When it comes to the environmental benefits, the most popular use of the public open spaces is adding the visual beauty, and greenery to the city's context. However, apart from these well-known benefits, Public open spaces have the potential to bring environmental sustainability from many aspects and disaster resilience which is not popular and hidden in the general planning and designing context. This paper investigates these hidden aspects of public open space and its contribution to make cities more sustainable. The research method involves literature analysis in the global context and observation in three different city contexts in United Kingdom, Netherlands and Sri Lanka. The findings suggest that mostly environment and disaster resilience related potentials of public spaces are less harnessed in cities context including restoring wildlife habitat, restoring ecosystems, providing emergency response and recovery, and mitigating future disaster risks. This study further discusses different approaches to bring these environmental and disaster resilience focused benefits to the city through public open spaces interventions.

Keywords: Disaster resilience cities; Public Open Spaces; Sustainable cities; Urban Resilience

ICSBE 2023-3

SIMULATION OF TIME DEPENDENT BEHAVIOUR OF RESTRAINED RC ELEMENTS

S.P.D. Danushka[1*], J.M.C.I. Jayasinghe[1], H.D. Yapa[1]

[1]Faculty of Engineering, University of Peradeniya, Peradeniya, 20400 Sri Lanka.

**Correspondence E-mail:: dilandanushka@eng.pdn.ac.lk, TP: +94765336754*

Abstract: Time-dependent behaviour of reinforced concrete occurs mainly due to the creep and shrinkage of the concrete material and is crucial in restrained structures, particularly for its serviceability performance. Typically, RC structures are designed for such effects over simplified rules stipulated in codes of practice. However, both creep and shrinkage are non-linear behaviours. Also, the shrinkage of concrete in the presence of reinforcement is complicated. This study first explored commonly used creep/shrinkage models. Second, using an available experimental result, the potential of those creep/shrinkage models to capture the time-dependent behaviour of reinforced concrete walls was assessed via a finite element (FE) study. It was identified that the Eurocode 2 (EC2) model was promising for both modelling normal strength applications and high strength applications. Subsequently, the numerical modelling was extended towards a case study where undesirable cracking was reported in beams and slabs of a multi-rise building. It was identified that most of the observed cracks were simulated reasonably by the FE model, and the model showed that the time-dependent behaviour was the main cause of the cracking of the structure. It was also highlighted that some of the cracks were due to design overlooks, and some were due to shortcomings in the design guidelines.

Keywords: Creep; Shrinkage; Time-dependent Behaviour; Crack; Reinforced Concrete

ICSBE 2023-15

TOWARDS SUSTAINABLE BUILDINGS: A REVIEW ON BUILDING MATERIAL SELECTION

S. V. Gurupatham[1*], C. Jayasinghe [1], P. Perera [2], R. Lepakshi [3]

[1] Department of Civil Engineering, Faculty of Engineering, University of Moratuwa, Moratuwa, Sri Lanka.

[2]Building Energy and Renewable System, Southern Alberta Institute of Technology, Calgary, Canada.

[3]Indian Institute of Science, Bangalore, India.

**Correspondence E-mail: sharonvanmathy@gmail.com, TP: +94766312518*

Abstract: With the ongoing global trend of urbanization, there has been a surge in demand for construction and building materials. However, this heightened demand has contributed significantly to environmental degradation through the extensive consumption of natural resources. In response to these environmental concerns, various novel materials are emerging as alternatives, emphasizing the critical nature of the selection process for building materials. Beyond the fundamental prerequisites of strength and durability, recent research has underscored additional considerations, encompassing environmental impacts, cost efficiency, and performance-related factors. Adopting a life cycle thinking approach better sustainable selection of materials over the long term. This article aims to comprehensively review the existing body of knowledge on methodologies for comparing and selecting building materials. Moreover, it aims to propose improved approaches that can enhance the efficiency of material selection, thereby contributing to the advancement of sustainable development. Material performance is influenced by a multitude of both quantitative and qualitative parameters. Experimental testing procedures, calculations, and computer simulations serve to quantify quantitative factors, while interviews, surveys, and on-site observations are employed to capture the qualitative preferences of end-users. In the combination of these diverse factors, Multi-Criteria Decision-Making (MCDM) methods play a pivotal role. Widely embraced techniques such as the Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarities to Ideal Solution (TOPSIS) are frequently utilized for the systematic comparison and ranking of alternatives. The insights derived from this comprehensive review are poised to inspire researchers to propose innovative, industry-centric approaches for the discerning selection of the most suitable building materials for construction purposes.

Keywords: Sustainability; Life cycle thinking approach; Multi-criteria-decision making, Construction material selection

ICSBE 2023-27

ANALYSIS OF MIDDLE INCOME HOUSING MARKET IN COLOMBO MUNICIPAL COUNCIL AREA: SOCIO-PSYCHOLOGICAL FACTORS FROM STATE SECTOR PROFESSIONALS' POINT OF VIEWS

R.P. Maladugala[1*], R.G. Ariyawansa [2]

[1]Chatered Architect, HY-d-DE Architects (pvt) ltd., Colombo 08

[2]Department of Estate Management and Valuation, University of Sri Jayewardenepura

**Correspondence E-mail: reshika27@gmail.com, TP: +94772858717*

Abstract: State sector professionals representing 32.6% of the total state sector employees reflects the well-educated and rational middle-income households working in the city of Colombo. The market trends in the housing industry shows residential developments being targeted towards these working professionals who commute to the city daily. However, the literature review revealed that the qualitative data such as motivational, attitudes and social status needs reflecting their socio-psychological characteristics which affects the housing satisfaction are not available adequately. More importantly satisfaction of these would improve the quality of housing which is a major factor in developing sustainable cities & communities. Identifying the gap and the importance of such qualitative data about the consumer group, the study focused on analyzing the socio-psychological factors determining the middle-income housing demand of the state sector professionals working in the CMC area. Considering the nature of data, a mixed method approach was followed using two basic methods. The data collected from in-depth interviews were analyzed using content analysis in identifying the socio-psychological characteristics. The qualitative data collected using a semi-structured questionnaire survey with a sample of 210 respondents were analyzed using Ordinal Logistic Regression analysis studying the influences of socio-psychological characteristics on their housing preferences. Contrary to the characteristics of the consumer, the results revealed that the study population is more focused on the safety, security, freedom and privacy than the esteem needs, as their major motivations in choosing their dwelling and such aspects have a larger influence on their housing preferences. The social status & esteem needs were communicated to a lesser extent and the influences of such needs on the housing preferences were shown to be very low. Further the analysis explained that this outcome may reflect the consumer's emotional reactions to the current economic situation in the country.

Keywords: Middle-income housing; Motivation; Attitudes; Social status; Housing preferences; State-sector professionals

ICSBE 2023-34

CLIMATE SMART ROOFING MATERIALS AND TECHNOLOGIES IN SRI LANKAN CONSTRUCTION INDUSTRY: SPECIAL ATTENTION TO EASTERN PROVINCE

R. Sathurshan[1*], K.B.A. Silva[1]

[1]Department of Construction Technology, Faculty of Technology, Wayamba University of Sri Lanka, Lionel Jayathilaka Mawatha, Kuliyapittiya 60200, Sri Lanka

**Correspondence E-mail: rajansathu6@gmail.com, TP: +94769966818*

Abstract: This research centers on analyzing the usage of roofing materials mainly in the Eastern province of Sri Lanka by assessing the knowledge of climate-smart roofing technologies through identifying barriers and proposing strategies to overcome these barriers. The research findings disclose that asbestos cement roof sheets and clay tiles are the most widely used roofing materials in the region. When choosing roofing materials, the public looks at factors such as indoor comfort, energy efficiency, and durability. The emerging climate-smart roofing materials and technologies can guarantee increased human comfort, low or non-toxic materials, waste reduction, improved indoor air quality, pollution prevention, reusability, recyclability, longer lifespan, and superior performance. However, several impediments hinder the widespread adoption of climate-smart roofing materials and technology. These barriers include a lack of awareness, higher initial costs, a lack of professional knowledge, a lack of demonstration and technology, and inadequate research investments. To overcome these barriers, strategies such as increasing public awareness, enhancing people's knowledge, promoting education and training, encouraging government leadership, nurturing collaboration among authorities, and supporting research and development are proposed. The research methodology integrates a comprehensive literature re- view, field observations, data collection, interviews, and questionnaires. Statistical analysis using SPSS was conducted, revealing a significant correlation between the number of qualitative variables. In conclusion, this research highlights the need to promote the adoption of climate-smart roofing materials and technologies in the Sri Lankan construction industry. By understanding the prevalent usage, industry knowledge, and over- coming barriers through effective strategies, the outcome suggests that the industry can progress towards sustainable and environmentally friendly roofing practices.

Keywords: Climate-smart roofing materials and technology; Sri Lankan construction industry; Eastern Province; Barriers and challenges; Adoption and promotion

ICSBE 2023-37

IMPACTS OF SUSTAINABLE GREEN HIGHWAYS CONSTRUCTION ON THE ECONOMY OF SRI LANKA: A SYSTEMATIC LITERATURE REVIEW

I.H.G.Y.M. Udari Yaparathne[1]*, Kavini Guruge[1]

[1]Faculty of Engineering & Construction, International College of Business & Technology, Kandy, Sri Lanka

**Correspondence E-mail: udariyaparathna@gmail.com, TP: +94763195018*

Abstract: Sustainability is a very popular and important concept nowadays. Highway construction has the potential to directly impact the environment, economy, and society of a country. Transportation authorities have begun developing sustainability rating systems that attempt to quantify sustainable design practices and elements of transport infrastructure. The "green highway' is a new concept that can be implemented when developing any road construction. Moreover, the construction sector is one of the majors which contributes to the GDP of Sri Lanka over the past decade. Considering the point, that Sri Lanka is a developing country, and facing an economic crisis, the traditional highway construction methods create a massive negative impact on the economic development of Sri Lanka. Accordingly, the price of construction materials along with other construction-related services has rapidly increased, therefore, it has become much more challenging to complete highway construction. Consequently, this research aims to figure out specific impacts on the economy of Sri Lanka by implementing the green highway concept in highway construction, through three main objectives; Identify the differences between the current practice of highways and sustainable green highways, Recognize the existing sustainable green highway methods in the world and identify the economic impact of the above methods to the Sri Lankan context. In addition, a systematic literature review has been done using one hundred fifty past research studies. Furthermore, this research paper provides an analytical comparison between the impact of traditional and sustainable green highway construction in Sri Lanka.

Keywords: Green highway; Construction; Economy; Sri Lanka

ICSBE 2023-38

DEVELOPMENT OF GEOPOLYMER PASTE USING BOTTOM ASH AND POTASSIUM HYDROXIDE AS THE PRIMARY POLYMERIZATION MATERIALS

G.G.R.N. Ranasinghe*, K.M.C. Konthesingha, A. Branavan, I.R. Upasiri, P.M.W.P. Kumara,

Department of Civil Engineering, University of Sri Jayewadenepura, Sri Lanka.

** E-mail: en91389@sjp.ac.lk, TP: +94773498865*

Abstract: Geopolymer concrete (GPC) is considered an effective alternative to conventional concrete because of its low embodied energy consumption and positive impacts on the environment. However, the unpopularity of GPC among the construction industries is mainly due to the high cost of production and safety-related issues. This study deals with developing geopolymer paste (GPP) in a more sustainable manner using bottom ash (BA) and granulated blast furnace slag (GBS) as precursors and potassium hydroxide (KOH) incorporated sodium silicate (Na_2SiO_3) based alkaline solution. The overall program is based on three stages: firstly, optimizing BA to GBS ratio among the selected replacement levels of 0%, 20%, 40%, 60%, and 80% by weight (using a fixed alkaline solution concentration of KOH: Na_2SiO_3: Water, 1.0: 1.5: 0.5 by weight); secondly, optimizing the dosage of KOH in alkaline solution among 10M, 12M, 14M, 16M 18M and 20M (using the optimum BA to GBS ratio); finally, optimizing the heat-curing temperature in the selected range of 60°C to 120°C at 20°C increments. These stages are done with respect to fresh and hardened state properties such as consistency, initial setting time, and flexural strength, and finally compared with the performance of conventional paste prepared using Ordinary Port- land Cement (OPC). Results revealed that consistency of 6 – 8mm, an initial setting time of 450 minutes, and a 7-day flexural strength of 4.8MPa is achievable with GPP containing 100% BA and KOH dosage of 16M cured at 120°C temperature. This is identified as the best proportion among the selected BA to GBS ratios and also more effective than the conventional OPC paste resulting in the same consistency, an initial setting time of 160 minutes, and a 7-day flexural strength of 3.5MPa. Moreover, the inclusion of GBS did not prove the satisfactory performance of GPP compared with the conventional cement paste.

Keywords: Geopolymer Paste; Bottom ash; Heat Curing; Consistency; Setting Time; Flexural strength

ICSBE 2023-39

DURABILITY OF ORDINARY CONCRETE MADE OF MANUFACTURED SAND AND OFFSHORE SAND

M.G.S. Asangi[1*], K.M.C. Konthesingha[1], A. Branavan[1], I.R. Upasiri[1], W.P.H.P. Weerasinghe[1], H.M.S.C. Rathnasiri[1], P.M.W.P. Kumara[1]

[1]Department of Civil Engineering, University of Sri Jayewadenepura, Sri Lanka.

**Correspondence E-mail: en91363@sjp.ac.lk, TP: +94789190710*

Abstract: Demand for river sand has been escalated nowadays. This creates a question on utilizing conventional fine aggregates and thus an increased usage of alternatives for concrete. Manufactured sand and offshore sand have been incorporated as the primary replacements for river sand by a few industries. In the present study, river sand was completely replaced by manufactured sand alone, offshore sand alone, and blending of manufactured sand and offshore sand at 25%, 50% and 75% replacement levels (by weight) in ordinary concrete to check the durability characteristics such as water absorption, sorptivity, weight and compressive strength losses in 10% sulfuric acid environment. Results revealed that the lowest water absorption was identified in concrete containing 50% manufactured sand and 50% offshore sand after 24 hours of complete immersion in water while the optimum resistance against sorptivity at 7 days was identified in concrete made of 25% manufactured sand and 75% offshore sand. Performance against the acidic environment was optimum in concretes made of 100% offshore sand and other blending mixtures. Overall, the mixtures all fine aggregate types except MS alone manifested better durability properties comparing to RS concrete. Therefore, all selected blended fine aggregates could be applied by completely replacing RS in concrete.

Keywords: Ordinary Concrete; River sand; Manufactured sand; Offshore sand; Durability

ICSBE 2023-54

INVESTIGATING SUBSTRTAE AMENDMENTS OF EXTENSIVE GREEN ROOFS FOR WATER SENSITIVE URBAN DESIGN

B.P.S.A. Premachandra[1], S. Himanujahn[2], B.C.L. Athtapattu[1,2*]

[1]Department of Civil Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka, Nugegoda, Sri Lanka.

[2]Centre for Environmental Studies and Sustainable Development, The Open University of Sri Lanka, Sri Lanka.

**Correspondence E-mail: bcliy@ou.ac.lk, TP: +94 77 75 77 321*

Abstract: The world is facing severe natural hazards like extreme rainfall, extreme droughts, urban floods, urban heat islands, etc. due to disturbances in the natural hydrological cycle with the combined effect of rapid urbanization and climate change. Water-sensitive urban design (WSUD) is a strategy aimed at managing stormwater in a sustainable manner. Green roofs are being used all over the world as a WSUD tool, and they are important both for stormwater retention and detention. However, with the substrate mix used in green roofs, it can act as a stormwater pollutant basin at times, mainly as phosphorous. This research is focused on analyzing the effect of green roofs on runoff quality using six small-scale roof platforms. Zeolite and biochar have been used as substrate amendments on green roofs. They were applied to green roofs independently and as a mixture of biochar and zeolite on five green roof platforms. Rainfall runoff data from green roofs from 30 rainfall events was observed for four months, from January to April 2023. pH, total phosphate, nitrate, and nitrite concentrations of runoff from each green roof were analyzed. Green roof substrate amended with 8% biochar and 10% zeolite has reduced the cumulative total phosphate load by 36% and the cumulative nitrate load by 57%, showing that the amendments made have substantially reduced the pollutants released from substrate. Hence, the green roof with zeolite-biochar amendments acts as an effective measure for the absorption of the limiting nutrients.

Keywords: Biochar; Green roof; Nutrient leaching; WSUD; Zeolite

ICSBE 2023-57

MITIGATING URBAN HEAT ISLAND USING COOL PAVEMENT STRATEGY: A CASE STUDY IN COLOMBO, SRI LANKA

D.M.A.M.S.R. Andradi[1], S. Himanujahn [2], R.A.K.K. Perera[3], B.C.L. Athapattu [1,2*]

[1]Department of Civil Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka, Nugegoda, Sri Lanka

[2]Centre for Environmental Studies and Sustainable Development, The Open University of Sri Lanka, Sri Lanka.

[3]Department of Mechanical Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka, Nugegoda, Sri Lanka.

**Correspondence E-mail: bcliy@ou.ac.lk, TP: +94 77 75 77 321*

Abstract: Continuous man-made changes in an urban area have led to the phenomenon called Urban Heat Island (UHI). UHI is an adverse condition of increasing urban temperature than its surrounding rural areas. Due to UHI, the thermal comfort of people has been affected badly and many negative impacts have occurred in society. The present research is focused on Cool Pavement as a mitigation strategy for UHI. Reflective concrete pavement was designed using waste glass, ground granular blast Furnace Slag, and white cement. Seven mix designs were created and strength and temperature graining tests were performed to identify the optimum ratio of material proportions. The results revealed that 10% replacement of slag and 10% replacement of white cement with OPC is the best ratio for the cool pavement, exhibiting superior solar reflection properties in comparison to conventional concrete. The Albedo of this invented CP was measured using the solar radiation sensor of a watchdog weather station. It was found to be 0.455 which highlights the reflective properties. Microclimate in the Fathima church area in Colombo, Sri Lanka has been analyzed in the current study. It is located in a highly metropolitan area which usually has high relative humidity and temperature. Field meteorological data were collected on the 1st of April 2023 using prepared electronic instruments. Invented pavement kept in the study area and compared with an existing concrete pavement. It was found that the invented cool pavement has a 1.4 K lesser surface temperature than conventional pavement. Further, this study explains the concept of UHI and different types of CP strategies.

Keywords: Urban heat island; Cool pavements; Reflective concrete pavement; Albedo

ICSBE 2023-68

APPLICATIONS OF CIRCULAR ECONOMY IN ROAD CONSTRUCTION PROJECTS IN SRI LANKA

A.M.U.D.Palukadawala[1]*, S. M. Dissanayaka[1]

[1]University of Peradeniya, Peradeniya, Sri Lanka

**Correspondence E-mail: palukadawala@yahoo.com, TP: +94777306686*

Abstract: The construction industry is one of the largest raw material-consuming industries in the world, as well as in Sri Lanka. The construction industry continues promoting linear practices that rely on 'take, make, consume, and discard'. The adoption of circular economy practices contributes to reducing waste and conserving raw materials on the earth. Despite the existence of circular economy (CE) practices worldwide, Sri Lanka has not fully implemented them. However, such practices have been observed in road construction projects in Sri Lanka, but they are not properly documented. The aim of this research is to assess the level of implementation of circular economy practices in road construction projects. Two road projects were examined through a qualitative study with professionals from the Client, Engineer, and Contractor organizations. Nine in-depth interviews were conducted for data collection, and the analysis was done through transcribing, coding, and categorizing the data. According to the study, the selected road improvement projects have implemented the R strategies of refuse, reconsider, reduce, reuse, repair, refurbish, remanufacture, reuse, recycle, and recover. A circular economy model was developed for road construction projects to serve as a guide for future users. The study findings can assist the construction industry and academia in implementing circular economy practices for road construction projects in Sri Lanka.

Keywords: Circular Economy; Road Construction Projects; R Strategies, 10R Framework

ICSBE 2023-70

BIO-CEMENTATION OF DEMOLITION WASTES AND RECYCLED AGGREGATES FOR SUSTAINABLE PRODUCTION OF PAVING BLOCKS

H. N. Muhanna[1], R. K. M. Niras[1], U. N. C. Prasadini[1], S. Gowthaman[1*], T. H. K. Nawarathna[1], M. Chen[2], S. Kawasaki[3]

[1] Department of Engineering Technology, University of Jaffna, Kilinochchi, Sri Lanka
[2] Graduate School of Engineering, Hokkaido University, Sapporo, Japan
[3] Faculty of Engineering, Hokkaido University, Sapporo, Japan
**Correspondence E-mail: gowtham@tech.jfn.ac.lk, TP: +94772911120*

Abstract: Concrete block pavements have recently become an attractive engineering system, increasingly used in parking areas, pedestrian walks, traffic intersections, container yards and low-volume roads. However, the production of paving blocks is in high demand of Portland Cement and natural aggregates. The exhaustive use of such resources has become a serious threat, resulting in scarcity of resources and negative environmental impacts. To alleviate the traits, the authorities heightened laws to restrict the construction practices that heavily contribute to carbon footprint. This study proposes the bio-cementation of demolition wastes and recycled aggregates as a new sustainable alternative for producing paving blocks. The method harnesses the bacteria containing active-urease to biochemically induce the cementation. The feasibility and efficiency of using five different types of demolition wastes were investigated. Recycled concrete coarse aggregates (R-CCA), recycled concrete fine aggregates (R-CFA), recycled concrete aggregate dust (R-CAD), recycled concrete mortar dust (R-CMD) and recycled brick aggregates (R-BA) were derived by crushing the building demolition wastes and prepared in standard moulds. The bacteria used herein were *Sporosarcina pasteurii*. During the batches of treatment, the bacteria culture was percolated into the specimens along with aqueous urea and calcium chloride. The evaluation program consisted of unconfined compressive strength (UCS) tests, scanning electron microscopy (SEM) analysis and the measurements of precipitation content. The SEM results revealed that the bio-cement treatment could induce the formation of calcium carbonate within the pores and facilitated the binding of aggregates in all the categories. However, the achieved UCS on R-CFA was the highest (~2 MPa), that on R-CCA was the next (~1.48 MPa), while that on R-CAD and R-BA were the worst. R-CMD achieved a moderate UCS (~0.6 MPa). The gradation and the nature of the waste material were found to determine the efficiency of strengthening and uniformity in cementation profile.

Keywords: Bio-cementation; Demolition waste; Recycled aggregates; Paving blocks; Ureolytic bacteria; Sustainability

ICSBE 2023-71

A COMPARATIVE STUDY OF THE GOLDEN RATIO AND THE BUDDHIST ARCHITECTURAL PROPOTIONS IN SRI LANKAN RITUAL SPACE

C Abeywardana [1*], C Palliyaguru [1], P Rathnayaka [1]

[1] Postgraduate, University of Kelaniya, Kelaniya, Sri Lanka.

**Correspondence E-mail: chandana_abeywardana@yahoo.com, TP: +940777716427*

Abstract: A considerable academic researches have been performed which based on concept of human mental and physical purification in rituals. Although none of them paid attention about mental and Physical balance using six senses of human in Buddhist rituals, structural balance and representation of microcosms. This study consists of the process that follow to obtain physical balance of all parties that participate in ritual. This comparative study is based on concept of the Buddhist architectural proportions, ritual space (microcosms) and Golden ratio. Qualitative and quantitative comparisons were done using archaeological evidence in Egypt, Asian and Sri Lankan traditions in order to achieve this objective. The Golden ratio is a mathematical ratio. It is commonly found in nature and has been used in design. Divine proportion which has been recognized for thousands of centuries in Egyptian, Greek and Rome ancient architecture. The shape of the Great Pyramid as based on the same religiously significant idealism of human proportions (Lucus ratio) used to depict the gods and the pharaohs in their reliefs, painting and sculpture. This analytical focus is mainly on major Sri Lankan Buddhist rituals (Pirith chanting and other rituals) which restore well-being of society. Use of space for Buddhist ritual procedure that follow to turn it into architectural proportions in Uposathagara, Relic of Tooth, Dagaba, Image house and Bodhigara, in order to achieve physical balance. These were rigid geometrical, highly formal and symmetric Architectural layout arrangement. This study analysis is mainly on the effect of sustainable environment to audience which based on concept of mental and physical balance using six senses of humans in Sri Lankan Buddhist rituals.

Keywords: Architectural proportions; Ritual space; Sri Lankan Buddhist ritual performance; Mental and physical balance; the Golden ratio.

ICSBE 2023-77

EMISSION REDUCTION POTENTIAL AND LAND-USE IMPLICATIONS OF DECARBONISING THE POWER SECTOR IN SRI LANKA

Lahiru Jayasuriya[1*], Gayan Subasinghe [2], Mevan Pathirathne [3], Thusitha Sugathapala [4]

[1]Department of Electrical and Electronic Technology, Faculty of Technology, Rajarata University of Sri Lanka

[2] UNDP Sri Lanka, Colombo

[3] Ceylon Electricity Board, Colombo

[4] Department of Mechanical Engineering, University of Moratuwa, Moratuwa.

**Correspondence E-mail: ltjayasu@tec.rjt.ac.lk, TP: +94712333410*

Abstract: Sri Lanka has ambitious plans to increase the share of renewable energy and introduce natural gas in the power sector to reduce GHG emissions as part of the Paris Agreement. Meanwhile, the agriculture sector and land-use sector come up with a different set of policies for example to increase domestic crop production and keep the forest cover in Sri Lanka to 30% of the land area. These policies may have constrained the availability of land for renewable energy development. As such, there are several interlinkages of policies made independently for different sectors in Sri Lanka which are not clearly understood. The Climate, Land-use, Energy, and Water Systems (CLEWs) is a well-established framework that allows the analysis of interdependent sectors in a country or region for better-informed policy-making. This paper presents an initial attempt to develop a CLEWs model for Sri Lanka. The study focuses on the energy sector policies that are existing, an Existing Policy Scenario, and a Perceived Policy Scenario with ambitious plans for renewable energy development. These scenarios were compared to a least-cost business-as-usual (BAU) scenario. The preliminary results showed that ambitious renewable energy deployment requires 7.6% of the available grass and scrublands which may lead to potential conflicts for agriculture, forestry, and economic development activities.

Keywords: CLEWs; Policy analysis; Renewable energy; NDC

ICSBE 2023-85

EFFICACY OF GREEN BUILDING RATING SYSTEMS TO PROTECT BIODIVERSITY OF SRI LANKA

S.U. Navimanage[1*], S.N.C.M Dias[1], S. Manawadu [3]

[1]The Open University of Sri Lanka, 21, Nawala,Nugegoda.

[3]University of Vocational Technology, 100 Kandawala Road, Dehiwala-Mount Lavinia.

**Correspondence E-mail: samadaraun@gmail.com, TP: +94711112498*

Abstract: Green building rating systems (GBRS) are acquiring a growing popularity international and local construction industries due to the increasing adverse impacts on natural environment by buildings. GBRS are considered as important tool for minimizing threats on natural environments using fewer natural resources for building construction and operation without sacrificing the user comforts. Therefore, GBRS are vital to be used in a country like Sri Lanka as it is a place rich in Biodiversity and being one of the 36 biodiversity hotspots in the world. Although the GBRS are internationally recognized as an effective tool for environmental protection, its real efficacy specifically on biodiversity protection is not explored yet. Thus, a mixed method research was carryout to evaluate the efficacy of biodiversity protection through GBRS. Initially LEED, GREENSLR and BLUE GREEN SL rating systems were explored to find the biodiversity protective criteria in their evaluation schemes. Due to a gap available in literature that how to clearly figure out BD protective criteria and points in GBRS, the_‘ “targets of post-2020 global biodiversity framework (P-2020 GBDFT)’ ” was taken as a reference material and mapped with GBRS criteria to highlight biodiversity protective criteria. Consequently 02 high rated green buildings, rated by above-mentioned GBRS were selected as case studies and explored the contribution of biodiversity protective criteria for the rating those have obtained. The results revealed all the considered GBRS are containing 65%-76% of biodiversity protective points. However, all the selected case studies have omitted 07 to 11 biodiversity protective criteria contain 08% to 25% biodiversity protective points, and still have managed to achieve Gold to Platinum ratings using other criteria. According the present study, it is revealed that GBRS are inefficient in biodiversity protection as it is not a must to obtain a high green rating though there is an impact to biodiversity. Therefore, the study recommends improving GBRS by adding separate biodiversity protective aspects, to highlight in biodiversity protective features and to increase biodiversity protective prerequisites in GBRS in protecting biodiversity.

Keywords: Biodiversity; Green Building Rating Systems; LEED; GREENSLR; BLUE GREEN SL

ICSBE 2023-91

FLEXURAL RESPONSE OF CEMENT MORTAR WITH ELECTRICAL CABLE WASTE

K.D.Y.G. Perera[1,2*], Y.L.F. Ahamed [2], H.M.C.C. Somarathna[1,2]

[1]Department of Civil Engineering, Faculty of Engineering, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka

[2]Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Ariviyal Nagar, Killinochchi 44000, Sri Lanka

**Correspondence E-mail: yahadisi96@gmail.com, yahadisi.p@sliit.lk TP: +94710868672*

Abstract: Electrical distribution cables are disposed when their length is insufficient and it's considered as it reaches the end of life, moreover eco-friendly disposal methods are not followed. This study aimed to improve the cement mortar system to meet the nowadays industry requirements with the inclusion of the aforementioned waste fibre extracted from the electrical distribution cables. An aluminium alloy fibre with a diameter of 1.35mm and 15.0mm long was used in four volume ratios as 0.5%,1.0%,1.5% and 2.0% to evaluate the flexural response of the Metal Fibre Reinforced Mortar system (MFRM). MFRM specimens were tested for flexural characteristics in accordance with ASTM C348. The observed stress vs. strain curves were critically analysed to compare the ultimate flexural strength, strain at the failure point, flexural modulus, strain energy at the failure and the post-peak behaviour of the system. Compared to the conventional mortar, the ultimate flexural strength of the MFRM was increased up to 35%. The failures of the systems were observed at higher strain values with the inclusion of fibre, particularly 85% increment was observed with 1.5% of fibre inclusion. Furthermore, the flexural modulus of the MFRM with 1.5% fibres was increased by 174% and the strain energy at the failure was also increased by 105% compared to the reference mortar. The stress vs. strain curves imply a curve softening pattern after the crack occurred because of the bridging of the matrices which minimizes the sudden failures of the system. The overall results highlighted that the inclusion of fibres improved the flexural capacity of the mortar and performed effectively at 1.5% fibre volume ratio and the improved mortar system can be used as a cost-effective sustainable building material because of the inclusion of the waste fibres.

Keywords: Cement mortar; Electrical distribution cable waste; Sustainable materials; Metal fibre reinforced mortar

ICSBE 2023-93

MANUFACTURING SUSTAINABLE PAVING BLOCKS USING POLYMER MODIFIED BIO-CEMENTATION

N.M. Mustak[1], H.R.H. Haseeb[1], R.M.P. Madushanka[1], A.M.G.G.G. Thilakarathna[1], T.H.K. Nawarathna[1*], S. Gowthaman[1]

[1]Department of Engineering Technology, University of Jaffna, Kilinochchi, Sri Lanka.

**Correspondence E-mail: hiranya@tech.jfn.ac.lk, TP: +94775017556*

Abstract: Demand of the Portland cement is unprecedentedly increasing due to urbanization and related bloom in construction industry. However, the Portland cement is not an ecofriendly material and contributes to several environmental problems. Finding an ecofriendly cementitious material is therefore a current need of the construction industry. In this research, the feasibility of polymer modified microbial induced carbonate precipitation (MICP) technique was assessed for sustainably producing paving blocks. In MICP, calcium carbonate ($CaCO_3$) bio-cement is produced artificially by the enzymatic urea hydrolysis, in the presence of calcium ions. Efficiency of the process can be accelerated by adding bio-polymers, which is herein referred to as polymer modified MICP. Experiments were conducted at the laboratory-scale, and quarry dust specimens were treated using *Sporosarcina pasteurii*, the ureolytic bacteria, with and without the addition of chitosan bio-polymer. Chitosan was introduced to the specimens by mixing and injection. Unconfined compressive strength (UCS) of the casted specimens were determined after 21 and 28 days. The outcomes indicated that the mixing method was more effective compared with the injection. During the injection, a thick $CaCO_3$ layer tended to form at top of the specimen due to the accumulation of the solutions, which inhibited further penetration of the solutions onto specimens. Compared with the control specimen, the specimen treated with chitosan exhibited higher UCS after 21 days of curing. Chitosan was found to assist in accelerating the formation of $CaCO_3$ and to develop a better bond between particles. Although both the specimens exhibited higher UCS after 28 days of curing, the specimen with chitosan showed lower UCS compared with the control. It was revealed that longer treatment with chitosan lead to the formation of higher $CaCO_3$, and which blocked the drainage path quickly than control specimen. By using polymer modified MICP, more sustainable paving blocks can be produced against conventional cement blocks.

Keywords: Bio-cementation; Chitosan; Paving block; Microbial induced carbonate precipitation; Compressive strength

ICSBE 2023-96

A STUDY ON ENHANCING AIR QUALITY AND THERMAL COMFORT USING NATURAL VENTILATION IN A LARGE AUDITORIUM

L. K. Gurusinghe[1], J. S. Manawasinghe[1*], P. B. Boyagoda [1]

[1]Faculty of Engineering, University of Peradeniya.

**Correspondence E-mail: janeesha.manawasinghe@eng.pdn.ac.lk, TP: +94712476808*

Abstract: Natural ventilation, the process of using outdoor air to cool and ventilate indoor spaces, is an energy-efficient and sustainable approach to building design. The E.O.E. Pereira theatre at the Faculty of Engineering, University of Peradeniya, with a capacity of 660 seats, has been identified to be uncomfortably warm during its use. This scientific writing aims to explore the existing problems and strategies to create a good air quality within the theatre. An extensive Computational Fluid Dynamics (CFD) simulation was carried out to identify the temperature variations, supply of fresh air and air flow patterns in the theatre on current operating configuration and on several improved configurations. The study explores key considerations such as louvre configuration, age of air, thermal comfort, and how external factors such as fans or blowers could be used to further improve the air quality inside the theatre. The findings and conclusions from the CFD simulation analysis provided useful insights with regards to the most suitable configurations that can be adopted to improve the comfort of the audience in the theatre. Considering financial factors, two configurations were chosen for further analysis. From the first configuration, which is economical, the simulation revealed that the audience would receive a 100% improvement when considering the age of air compared to the current operating configuration, where the age of air is 280 seconds. The thermal comfort is also improved by 3^{o}C in the neighbourhood of the audience. Alternatively, when comparing the costly configuration, the results revealed a 3.5^{o}C improvement in thermal comfort and an improvement of the age of air to 170 seconds near the audience, but conditions upon the stage improved drastically. The findings of this study can be used in implementing design measures that promote indoor air quality, thermal comfort, and energy efficiency.

Keywords: Natural Ventilation; Sustainable Buildings; Computational Fluid Dynamics; Age of Air; Thermal Comfort

ICSBE 2023-103

EFFECT OF ENERGY DEMAND AND THERMAL COMFORT OF LOW INCOME HOUSES; CASE OF MONARAGALA DISTRICT

KSKNJ Kudasinghe[1*], H Munasinghe [2]

[1]General Sir John Kotelawala Defence University

[2]George Brown College, Canada

**Correspondence E-mail: ksknjkudasinghe@kdu.ac.lk*

Abstract: Within the next 30 years it is estimated that half of the world's population will reside in developing countries of Asia and Africa. Thus tropical urbanization increases the demand for places for people to live and the increasing level of energy demand. The domestic sector dominates the electricity consumers of the country and evident for the highest end user energy demand of 34% on national grid. Although the national electrification level is 99.7% there are few districts which have not achieved the status of 100% accessibility to electricity. This study explores the energy demand levels and thermal comfort aspects of the low income houses of the poverty stricken district of Monaragala. This district contributes 3.2% to the total poverty levels of Sri Lanka. Findings indicate 25% of the sample fall into this category of being below the poverty line, which is higher than the 23% national estimate. Results indicated that the mean electricity consumption is 51 kWh household-1 month-1 whilst only 25% had access to clean cooking fuels. Furthermore, findings indicated that the internal spaces are overheated with an operative temperature of 32.2°C and this temperature do not comply to ASHRARE 55 standards. The required comfort temperature, according to the comfort temperature equation is 28.92°C. However, the investigated operative temperature is 3.3°C more. Thus, these findings highlight the importance of implementing a housing approach for low income houses, prioritizing climate change and well-being of the occupants in tropical climate context.. This accomplishes the interaction of several United Nations Sustainable Development Goals (SDGs), with six principally significant SDGs such as poverty (1), health (3), infrastructure (9), inequalities (10), cities (11) and climate (13).

Keywords: Thermal comfort; Energy demand; Low income houses; Tropical urbanization

ICSBE 2023-116

LIFE CYCLE COST ANALYSIS OF GREEN BUILDING PROJECTS IN SRI LANKA

CV Rajasekara[1*], DVH Dodangoda [1], WN Kawmudi [1]

[1]Department of Quantity Surveying, Faculty of Built Environment and Spatial Sciences (FBESS), General Sir John Kotelawela Defence University, Southern Campus, Sri Lanka

**Correspondence E-mail: 37-qs-0030@kdu.ac.lk, TP: +94715950494*

Abstract: Increasing green construction adoption is at the forefront of the global building industry as society pushes towards greater sustainability. Green building has risen to the top of the priority list for the construction sector as the globe advances towards greater sustainability. While Sri Lanka is now experiencing an energy and economic crisis, green building ideas can support the economy by advancing the building industry. If Sri Lanka adopts the green building concept within the next 30 or 40 years, it might be able to transform revenue-generating prospects in the construction industry. People only take into consideration the construction's initial cost, not the total cost over the course of its whole life. It is preferable to consider a building's Life Cycle Cost (LCC), which includes cost parameters for maintenance, operational and services cost parameters. Therefore, the main objective of this study is to identify the factor that has the most impact on LCC in a green building and to provide solutions to reduce that factor's impact to further reduce LCC. The necessary authorities were surveyed using a questionnaire and interviewed online, allowing for a full analysis of the study. This uses both quantitative and qualitative analysis to validate findings and offer suggestions based on opinions from many parties in the building industry. The services cost was the cost data for LCC that is most affected, according to the studies. Further, this study made suggestions for reducing expenses in sustainable building to ultimately lower LCC. This research study will be relevant for Sri Lanka to address the current economic crises by taking monetary account of the green construction idea.

Keywords: Green Building; LCC; Services cost; Maintenance cost; Operational cost

ICSBE 2023-143

FLEXURAL BEHAVIOUR OF REINFORCED RUBBERIZED CONCRETE BEAM

A.P.I Jayanath[1*], J.C.P.H Gamage [1], E.R.K Chandrathilakae [1]

[1]Department of Civil Engineering, University of Moratuwa, Sri Lanka.

**Correspondence E-mail: isuru98j@gmail.com, TP: +94752845986*

Abstract: The utilization of discarded tires as aggregate for concrete can reduce environmental pollution, and the usage as raw materials, leads to sustainable development and efficient economic growth. Majority of research studies have been focused on the development of rubber-based concrete for non-structural applications. Even though little research studies had shown the suitability of rubberized concrete for structural purposes, none of them have assessed the feasibility for structural applications. In series of four point bending tests were conducted to investigate the behaviour of reinforced rubberized concrete beams under flexure. The results indicate a reduction of 23.07% and 12.5% in moment capacity and workability and increment of deflection compared to normal reinforced concrete beam. The results showed that the compressive strength and splitting tensile strength of the concrete matrix was significantly reduced in 35.5% and 53% with the inclusion of the rubber aggregates. The SEM results showed that the presence of rubber particles in the concrete matrix increased porosity and decreased microstructural compactness, leading to weaker interfacial bonding between rubber particles and the cement paste. However, it exhibited 32.66% higher flexural toughness, indicating its ability to absorb and dissipate energy.

Keywords: Rubberized concrete; Flexural strength; Cyclic load response; Load-deflection

ICSBE 2023-144

DEVELOPMENT OF A NOVEL WASTE BASED INSULATED PLASTER WITH WATER PROOFING ABILITY FOR ROOF SLABS

D.D. Weerakkody[1*], J.C.P.H. Gamage [1], E. R. K. Chandrathilaka[1], Kajanan Selvaranjan[2]

[1]Department of Civil Engineering, University of Moratuwa, Sri Lanka

[2] Department of Civil and Structural Engineering, University of Sheffield

**Correspondence E-mail: ddweerakkody@gmail.com, TP: +94764301129*

Abstract: The cement industry contributes significantly to global greenhouse gas emissions, and improving the thermal performance of buildings is crucial for reducing energy consumption and achieving thermal comfort. The building envelope, particularly roof slabs, plays a vital role in heat transfer, accounting for 50-60% of overall heat exchange. Thermal insulation is an effective solution for energy-efficient thermal comfort, and Rice Husk Ash (RHA) is a sustainable material that can enhance thermal insulation and reduce operational energy in roof slabs. Inducing pore structure using RHA for low thermal conductivity and the filling the gaps and voids in micro-structure with non-conductive Waste Brick Powder (WBP) were main concepts of developing this dual-purpose protection while ensuring sustainable construction practices and the reduction of greenhouse gas emissions with controlled waste disposal which turns to timely needed sustainable building materials. This novel product indicated 69.5% and 89% lower values of thermal conductivity and water proofing abilities, respectively when compare with average values of available corresponding products in the market.

Keywords: Thermal Comfort; Waste Utilization; Thermal Insulation; Waterproofing; Green Building Material

ICSBE 2023-153

FRAMEWORK TO DECIDE ON THE APPROPRIATENESS OF RECYCLED CONCRETE AGGREGATES AS A CONSTRUCTION MATERIAL IN DIFFERENT CONSTRUCTION PROJECTS IN SRI LANKA: WITH AN INSIGHT OF THE COST BENEFIT ANALYSIS

A. M. M. Hiranya[1*], T. Wijesinghe [1], B. K. C. Perera [1]

[1]Department of Quantity Surveying, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka.

**Correspondence E-mail: mayoshihiranya99@gmail.com*

Abstract: Discarded concrete directly accounts for about 50% among the overall construction and demolition waste. And enormous pollution and energy consumption during concrete production, together with rising demand for concrete, pose a constant danger to environmental sustainability and human health. Since zero waste and zero pollution are hard to be achieved in the construction industry, numerous studies on concrete recycling technologies and benefit assessments have been carried out over the past several decades. The attempts find the ways of dealing with discarded concrete is one of the tasks aligned towards the aforementioned goal. As the construction industry pushes towards sustainability, raw material substitutions such as Recycled Concrete Aggregate (RCA) have great potential to mitigate the negative consequences of concrete while maintaining the engineering capabilities. However, the concept is yet to be implemented effectively and commercial scale in Sri Lankan construction practices. Inadequate knowledge, lack of technology and the absence of a proper framework may be the primary causes of that. In order to optimize the utilization while achieving economical, environmental and social benefits, all the costs and benefits should be addressed to arrive at an objective decision. Therefore, this study mainly focused on developing a framework to assess the appropriateness of utilizing reclaimed concrete aggregates in different construction projects in Sri Lanka. The study anticipated a mixed methodology that includes eight (08) expert interviews and a questionnaire survey. Through the manual content analysis, the process of recycled concrete aggregate production and all the related cost and benefit centers were identified. The findings were ranked based on the significant impact. Finally, a framework is presented as a guideline to decide on the appropriateness of recycled concrete aggregates in place of natural aggregates in a construction project in Sri Lanka.

Keywords: Construction and demolition waste; Cost-benefit centers; Framework; Natural aggregates; Recycled concrete aggregates

ICSBE 2023-154

IMPACT ON LARGE-SCALE BUILDERS OF THE CONSTRUCTION INDUSTRY IN SRI LANKA IN THE FACE OF THE CURRENT ECONOMIC CRISIS

K. U. Ranjith[1], K. A. N. Gunarathna [2], J.U. Kumarathunga [1*]

[1]Freelance Quantity Surveyor.

[2]Lecturer, Sri Lanka Institute of Information Technology, New Kandy Road, Malabe, Sri Lanka

**Correspondence E-mail: janauvasara@gmail.com, TP: +94767333391*

Abstract: The construction industry plays a significant role within the country's national economy in terms of generating wealth and improving living standards. This strong correlation and the resulting contribution to the GDP warrant the need to ensure that all construction projects are executed as efficiently as possible. Since 2022, Sri Lanka has been experiencing its worst economic crisis in decades. This has had a detrimental effect on many economic sectors, including the construction industry. In order to take remedial actions, it is necessary to conduct an in-depth analysis of the ways in which the industry has been impacted negatively. The scope of this study focuses on large-scale Sri Lankan builders, and it aims to identify the payment problems as well as other constraints faced by them due to the economic crisis. The objectives set to achieve the stated aim were: explore the impacts of the current economic crisis in Sri Lanka with special emphasis on the construction industry, determine the impact of the economic crisis on large-scale builders, and identify existing strategies used by large-scale builders to avert negative impacts and provide recommendations for better performance. Preliminary interviews were conducted with construction industry experts (n=5) and their responses were used as a guideline when preparing the questionnaire survey to identify the main issues faced by large-scale builders within the industry. The responses (n=42) concluded that the construction industry in Sri Lanka has been greatly affected by the economic crisis, and that the uncontrolled increase in construction material prices had serve impact and worsen the cash-flow issues faced by large scale builders. The study recommends that rather than resorting to local projects, large-scale builders would better opt to undertake international projects during this time.

Keywords: Economic Crisis; Large-scale builders; Construction Industry; Improvement Stratergies

ICSBE 2023-164

ASSESSMENT OF THERMAL COMFORT LEVELS IN TYPICAL SCHOOL BUILDINGS IN THE SOUTHEASTERN REGION OF SRI LANKA

M.N. Nifal [1*], A.M.M. Zeeras [1], J.A. Thamboo[1], A.M.A. Saja [2]

[1]Department of Civil Engineering, South Eastern University of Sri Lanka, Oluvil 32260.

[2]Department of Interdisciplinary Studies, Faculty of Engineering, South Eastern University of Sri Lanka,Oluvil 32260.

**Correspondence E-mail: nifalmn@gmail.com, TP: +94 778329210*

Abstract: Thermal comfort inside the learning environment has a substantial impact on students' performance and mental acuity. Providing a thermally comfortable condition inside the classrooms is a challenging task, in regions where the climate is hot and humid. This study focused on examining the thermal comfort levels in naturally ventilated typical classrooms in Sri Lanka. A study was conducted to assess thermal comfort levels in two different school buildings in the South-Eastern region of Sri Lanka. The assessments included measurements of climatic parameters and a questionnaire-based survey with students to assess thermal comfort levels using ASHRAE thermal sensation scale in the classrooms. The mean indoor temperature and relative humidity measured during the study period were 30.5 ºC and 75.8% respectively. The survey revealed that 68.5% of students voted within the comfort band (-1 to +1) according to ASHRAE thermal sensation scale. The thermal preference of students showed a preference towards a cooler sensation and an increased air movement. The data analysis indicated that for these naturally ventilated school buildings, a neutral temperature of 28.5 °C and a comfort range of 25.9 °C to 31.0 °C, with 80% acceptability, are applicable. The Griffith's method predicted a mean comfort temperature of 28.9°C.

Keywords: Adaptive strategies; Naturally ventilated classrooms; School buildings; Thermal comfort

ICSBE 2023-167

FRAGMENTATION ANALYSIS OF PERI-URBAN NATURAL ECOSYSTEM; THE CASE OF BAHIRAWAKANDA TERRAIN, KANDY, SRI LANKA

K.Y.M.Sirimewan [1*], J.H.Dharmasena [1]

[1] University of Moratuwa, Katubedda, Sri Lanka.

**Correspondence E-mail: sirimewanyasith@gmail.com, TP: +94773355503*

Abstract: Development impact on natural ecosystems is especially a major problem in the developing world. This is mainly due to the rapid urban developments and inadequate concern of managing natural ecosystems. Urban and peri- urban natural terrain ecosystems are the most vulnerable ecosystems, facing this predicament. This research investigates, using the remote sensing field, the ecological deterioration due to the neglect of natural terrain in the rapid urbanization process. In Sri Lanka, the field of remote sensing is not widely applied in analysing urban issues. The study focuses on understanding and calculating the ecological impact with reference to Kandy Bahirawakanda natural peri-urban terrain ecosystem based on remote sensing field. There are four ecological impact indexes that can be used to measure the impact using remote sensing technology. This paper uses the ecological patch fragmentation index as the measuring device to measure the increase of fragmentation of ecological patches. This approach provides a clear insight in to how a singular ecological patch fragments in to the separate patches and the increase of gaps between those patches. This provides a very good physical and visual indication of one important aspect of the destruction of natural ecosystems. This is very much pertinent to current Sri Lankan context as peri-urban developments, especially new residential developments/urban planning and subdivisions are carried out with little regard to ecological integrity in the area. While there is some protection for government identified ecological reserves there is practically no identification or protection for general integrity and health of broader ecological network of an area.

Keywords: Patch fragmentation; Patch isolation; Peri-urban; Natural ecosystems; Remote sensing

ICSBE 2023-174

EXPERIMENTAL INVESTIGATION ON POROUS CONCRETE FOR SUSTAINABLE DRAINAGE SYSTEMS

D.R.T. Niwunhella [1*], D.N.S. Kalpadeep [1], N.G.P.B. Neluwala [1], A.J. Dammika [1]

[1]Faculty of Engineering, University of Peradeniya, Sri Lanka

**Correspondence E-mail: rusiruniwunhella97@gmail.com, TP: +94717578068*

Abstract: Flooding in urban areas caused by unpredictable high-intensity rainstorm events due to a lack of sufficient drainage infrastructure has become a major problem nowadays. Urbanization and climate changes in urban cities have made drainage systems overflow, which results in urban floods. Introducing a sustainable urban drainage system is an effective solution to control urban floods. Furthermore, it will control downstream flooding and it will reduce the deterioration of river water quality. Porous concrete drainages can be a good alternative in urban areas as it can infiltrate excess runoff into the soil. In many countries, construction debris has become a severe environmental issue. So, it is an environmentally friendly approach to reuse or recycle construction wastes for the manufacturing of porous concrete. Porous concrete has already been used to create pavements, parking lots, and cover slabs. But only a few researchers have studied different mix designs for porous concrete. This study is based on eight mix designs, which will be comprised of without fine aggregates and with fine aggregates mix designs. 12.5 - 25 mm coarse aggregate size weight was changed for the first 4 mix designs. The other 3 mix designs were comprised of fine aggregates and changed percentages of fine aggregates by 10%, 20% and 30%. A comparison of normal porous concrete versus construction waste porous concrete was studied as the final experiment. When the coarse aggregate percentages changed from 15% to 75%, infiltration rates increased from 133.6 inches/hr to 448 inches per/hr and the seven-day compressive strength varied from 14.3 MPa to 12.1 MPa. When fine aggregates were introduced from 10% to 30%, the compressive strength increased from 16.5 MPa to 18.21 MPa and the infiltration rates decreased from 600 inches/hr to 320 inches/hr. Test with construction waste yielded 16.28 MPa strength and 1400 inches/hr infiltration after 28 days showing its potential to be used in urban areas.

Keywords: Sustainable drainage systems; Porous concrete; Compressive strength; Infiltration rate; Urban flash flood controlling

ICSBE 2023-188

INVESTIGATION OF PROPERTIES OF CONCRETE RELEVANT TO EARLY-AGE THERMAL CRACKING

R.M.S.S. Karunarathna [1*], S.M.A. Nanayakkara [1]

[1]Department of Civil Engineering,
University of Moratuwa, Sri Lanka
**Correspondence E-mail: supun.shalitha097@gmail.com , TP: +9478 977 9248*

Abstract: The occurrence of early-age thermal cracking presents a significant challenge to the durability and safety of concrete structures, leading to heightened maintenance and repair expenditures. Various factors influence the occurrence of early-age thermal cracks in concrete. Among that Temperature difference of member, Coefficient of Thermal Expansion of concrete (CTE - α_c) , Coefficient for the effect of stress relaxation due to creep under sustained loading (K_1) ,Restraint Condition. Tensile stress capacity of the concrete at that age is important. This study primarily focuses on the CTE of concrete during early ages and K_1. Charnockite gneiss stands as the most commonly used aggregate in Sri Lanka's construction industry. However, the design codes and guidelines do not provide the α_c value for the concrete produced using this aggregate. Additionally, the study delves into investigating the basis and value of the coefficient (K_1) responsible for stress relaxation due to creep under sustained loading. To address this issue, an innovative test setup utilizing available techniques was developed to accurately measure α_c values. The obtained results indicate that the CTE of the concrete samples exceeds the conventional value used in Sri Lanka (10 με/C), highlighting an increased risk of cracking due to temperature changes. Furthermore, find the K_1 factor is not a constant value for every situation to estimate the restrain strain by the equation. The K_1 factor's variability necessitates the development of a sophisticated finite element model to estimate its impact accurately. This model takes into account diverse factors affecting early-age concrete behavior and offers a robust method for predicting stress relaxation. By providing insights into thermal characteristics and addressing a critical issue in construction, this research contributes to more informed design and construction practices, ultimately enhancing the sustainability and safety of built environments.

Keywords: Concrete Early-Age Thermal Cracking; Coefficient of Thermal Expansion (CTE) of Concrete; Charnockite Gneiss; Coefficient for the effect of stress relaxation due to creep under sustained loading; Creep Ratio

ICSBE 2023-199

OPTIMIZING SOLAR ENERGY HARVESTING THROUGH AI-BASED DUAL-AXIS SOLAR TRACKING SYSTEM WITH REMOTE MONITORING

M.T.U.D. Mallikarathne1*, A.M.H.M. Abeysinghe 1 , W.P.Madhushani Perera2 G.A.H.K.M. Gamlath2

[1]*Department of Instrumentation and Automation, Faculty of Technology, University of Colombo*
[2]*Department of Engineering Technology, Faculty of Technological Studies, Uva Wellassa University*
**2017t00042@stu.cmb.ac.lk, TP: +94742413659*

Abstract: The solar harvesting system is popular these days since it produces clean and effective energy. The system's efficiency can be maximized by positioning the solar panels at the exact angle and direction dictated by the motion of the sun. This research project uses a solar tracking system that follows the sun along both its horizontal and vertical axes. The main goal is to develop a clever tracking algorithm that precisely lines up the solar panel with the position of the sun in order to maximize energy production from solar radiation. To determine the effectiveness of the data-driven dual-axis solar tracking system, extensive testing and assessment are carried out. In comparison to fixed solar installations, the research intends to quantify the increase in energy output made possible by careful solar panel orientation. The results of this study offer important new perspectives on the conception and application of clever solar tracking systems based on four LDRs, a Bluetooth module, a current sensor, and a voltage sensor. A simple and accessible method for raising awareness of sustainable renewable energy practices and improving the efficiency of solar energy harvesting is provided by the incorporation of MIT App Inventor for remote monitoring. This project aims to significantly advance the design and application of intelligent solar tracking devices by utilizing advanced data analytics and real-time remote monitoring. The data-driven methodology used in this study offers encouraging potential for increasing the usage of solar energy and hastening the deployment of clean and effective solar power technology within the field of artificial intelligence, the Support Vector Regression (SVR) method. This unity of purpose emphasizes SVR's ability to correctly forecast angles for efficient energy harvesting. It is important to emphasize, however, that the successful deployment of SVR involves painstaking data preprocessing, careful parameter adjustment, and stringent validation processes.

Keywords: Solar tracking system; Data-driven optimization; LDRs (Light Dependent Resistors); Voltage & Current sensor; Remote monitoring app; Support Vector Regression (SVR);

ICSBE 2023-202

KITHUL WOOD REBARS FOR LIGHTLY LOADED ONE-WAY SLABS

H.L.I.D. Premathilake[1*], I.S.K. Wijayawardane[1]

[1]Department of Civil Engineering, The Open University of Sri Lanka, Nawala, Nugegoda.

**Correspondence E-mail: hlisurud@gmail.com, TP: +94778052784*

Abstract: Steel serves as an optimal material for reinforcing concrete due to its desirable properties. However, it's a non-renewable material and incurs a high material cost as well as a high carbon footprint. The structural timber emerges as a renewable, sustainable, and cost-effective alternative. Some timber species such as Kithul wood (Caryota Urens) and bamboo (Bambusa vulgaris) exhibit commendable tension capacities due to their fibrous structure. Very low ductility, low fire endurance are the governing factors for not using timber as the tension reinforcement in concrete, but it can be used in concrete slabs as the distribution bars, where the main purpose is crack controlling. In this study, the technical and economic feasibility of using Kithul wood rods as a substitute material for distribution steel in lightly loaded one-way slabs is checked. Testing for material properties of Kithul wood was done according to BS373:1957 standard. Three slab panels having dimensions 1200 mm×600 mm×100 mm were cast using 10 mm×10 mm square Kithul rods and 10 mm diameter steel reinforcing bars. Different arrangements of the distribution reinforcement were considered to identify the flexural behaviour of the reinforced concrete one-way slab panels having Kithul wood as distribution reinforcement. All the concrete slab panels were made using grade 25 concrete and after curing for 28 days they were tested for flexure under 3-point loading test. The control specimen, which is having only steel reinforcement showed the highest flexural capacity, whereas other two slab panels containing Kithul rebars showed a flexural capacity more than 79% of flexural capacity of the control specimen. On the other hand, the new slab panels containing Kithul rebars are cost effective and with a proper design, they can be used for lightly loaded one-way concrete slabs.

Keywords: Kithul wood rebar; Distribution reinforcement; Renewable material; One-way concrete slab; Flexural strength; Lightly loaded slabs

ICSBE 2023-210

STRUCTURAL FEASIBILITY OF PRECAST FIBER-REINFORCED LIGHTWEIGHT CONCRETE WALL PANELS

S.B.M. Subasinghe[1*], I.S.K. Wijayawardane[1]

[1]Department of Civil Engineering, The Open University of Sri Lanka, Nawala, Nugegoda.

**Correspondence E-mail: sbsubasinghe@gmail.com, TP: +94718467989*

Abstract: Lightweight concrete is one of the newly emerging building construction materials in Sri Lanka and it's becoming popular as it reduces self-weight of the structure, ease of handling, reduced cost for finishes, fast construction. In this study, suitability of fiber-reinforced light weight material for precast partition wall system and its cost effectiveness were investigated. The Aerated Autoclaved concrete (AAC) was used as the light weight material and natural Bristle type coir fiber was used as the fiber-reinforcing material. The light weight property in AAC is gained by making air entrapped artificially by chemical foaming agents. The main objectives of the study are identifying the optimum coir fiber mix proportion for AAC, which gives the maximum compressive strength and investigate the flexural behavior of the coir fiber mixed AAC wall panels. The compressive test specimens ($100\ mm \times 100\ mm \times 100\ mm$) were produced by mixing of 1.5% to 3.0% coir fiber with AAC. Three AAC wall panels having a size of $1200\ mm \times 600\ mm \times 150\ mm$ were tested for lateral loads in accordance with BS EN1052: part 2:2016. According to the experiment results, the average flexural strength of AAC-Coir fiber wall panel was 0.51 N/mm^2. The AAC-Coir fiber wall panels showed significantly high lateral load resisting capacity and it is more than recommended value given in BS-5628: part 1:1992 for walls constructed with burnt clay bricks which is 0.4 N/mm^2. Therefore, the proposed wall panels can be used for the non-load bearing partitioning wall construction. According to the cost comparison results, the fiber-reinforced wall panels are cost effective when compared with the typical AAC wall systems.

Keywords: Lightweight concrete; Precast wall panels; Autoclaved Aerated Concrete; Coir fibre; Flexural strength; Fly ash

ICSBE 2023-211

EFFECTIVENESS OF IMPLEMENTING SUSTAINABLE PUBLIC PROCUREMENT (SPP) PRACTICES IN THE SRI LANKAN CONSTRUCTION INDUSTRY

E. M. P. G. A Ekanayake[*1], C Jayasinghe [1], K. P. H Perera[1], K. V. J. P Ekanayake [2]

[1]Dept. of Civil Engineering, University of Moratuwa, Sri Lanka.

[2]Dept. of Electrical and Computer Engineering, The Open University of Sri Lanka.

**Correspondence E-mail: anushke27@gmail.com, TP: +94775415836*

Abstract: The need for adequate public procurement practices has imposed several construction industry issues, leading to project delays and inefficient use of public funds. To improve the situation, Sustainable Public Procurement (SPP) practices would be a better start position on revival. However, the literature review emphasises limited studies conducted on SPP practices related to the construction industry in Sri Lanka. Hence, the primary focus of the research revolved around crafting an implementation framework for SPP practices within the Sri Lankan construction industry, aiming to address existing gaps and promote greater sustainability and responsible procurement practices within the sector. A detailed literature review was conducted to identify and prioritise challenges and key drivers in implementing SPP practices in local and foreign construction industries. A pre-survey was conducted with ten government personnel working in the construction industry to assess their awareness and identify challenges and key drivers faced by SPP practices in the construction industry. Pre-survey and literature review results were used to develop the proposed framework and validated through an online survey. Thirty-four responses were collected from government and semi-government officials in the construction industry. Four responses were discarded due to irrelevant answers, and 30 were used for data analysis. Based on the data analysis, ten challenges and six key drivers were used to develop the framework. The implementation framework was created with the support of a literature review and the feedback of subject matter experts (SME). The subject matter experts reviewed and validated the framework, and feedback was incorporated. The results of this study benefit policymakers and institutional practitioners handling construction procurement works.

Keywords: construction industry; public procurement; sustainable public procurement practices

ICSBE 2023-214

EFFECT OF THE FLEXURAL STRENGTH ON FINGER-JOINTED WOOD WITH 25mm FINGER LENGTH AND 19 mm FINGER LENGTH

C.K. Muthumala[1*], K.D.A. Abeysekara[2], P.L.A.G. Alwis[2], Sudhira de Silva [3], K.K.I.U. Arunakumara [4]

[1] Research Development and Training Division, State Timber Corporation, Sri Lanka

[2] Department of Agric. Engineering, Faculty of Agriculture, University of Ruhuna

[3] Department of Civil and Environmental Engineering, Faculty of Engineering, University of Ruhuna

[4] Department of Crop Science, Faculty of Agriculture, University of Ruhuna

[*]Corresponding author: ck_muthumala@yahoo.com, Tel ; +94777834716

Abstract: Timber is a renewable resource and widely used for furniture manufacturing and construction industry in the world. Finger Joint is an effective method to minimize the timber wastage arising in the timber related industries. This study was undertaken to effect of the bending test on finger-jointed wood with 25mm finger length and 19 mm finger length. For bonding purposes, SWR adhesive (PVAc) D3 type glue was used at normal exposure conditions. Well-seasoned , defects free wood materials from seven timber species; Grandis, Jack, Kumbuk, Mahogany, Pine, Satin and Teak were selected for this study. BS 373:1957 was used as standard for tests. Mechanical properties were performed by Universal Testing Machine (UTM 100PC). Results were analyzed using ANOVA. Results revealed that there is a significant relationship between MOR and finger length ($P<0.05$) and there is no significant relationship between MOE and finger length ($P>0.05$) and can be recommended, horizontally oriented 19 mm finger jointed specimens suitable for finger joint applications than 25 mm finger jointed specimens.

Keywords: Finger joint; Finger length; Mechanical properties; Wood

ICSBE 2023-223

SUITABILITY OF PLASTIC MODIFIED ASPHALT CONCRETE (PMAC) IN SRI LANKAN CONTEXT

N. M. R. S. P. Nawela*, Dr. J. Samaranayake

AGC Innovate (Pvt) Ltd., No. 34, Ward Place, Colombo 07, Sri lanka.

**Correspondence E-mail: sajini@agcinnovate.com, TP: +94 701750150*

Abstract: This research paper explores the suitability of utilizing non-recyclable waste plastics, specifically Low-Density Polyethylene (LDPE) and Biaxially Oriented Polypropylene (BOPP), to modify asphalt concrete (AC) within the Sri Lankan setting. With the escalating environmental burden posed by non-recyclable plastic waste, this study investigates the potential of incorporating LDPE and BOPP into AC mixes, aiming to address both waste management issues and pavement performance enhancement. By analyzing parameters of the PMAC, it revealed that all the properties have been increased compared to the conventional AC. Similarly, one of the performance indicators of the road surface such as macrotexture depth, and also the skid resistance have been complying with the specification requirement. Based on the existing literature, the durability of PMAC roads has been ensured, and this study seeks to confirm the durability through comprehensive testing. Moreover, the production process for PMAC, along with the subsequent road pavement steps, closely resembles that of conventional Asphalt Concrete (AC). Test results are proven that the emissions incorporated with PMAC are no different than the conventional AC. Additionally, measures have been implemented to regulate the sizes of plastic particles, thereby mitigating the occurrence of microplastics. This guarantees PMAC as an ecologically sustainable substitute for conventional AC. PMAC reduces the bitumen content compared to conventional AC saving foreign currency. The outcomes of this research hold significant implications for both waste management strategies and improvement of conventional AC in Sri Lanka. By incorporating non-recyclable waste plastics as a raw material, the study offers practical recommendations for sustainable road construction. In conclusion, this paper contributes to the discourse on the suitability of PMAC in the Sri Lankan context, emphasizing its potential to simultaneously address non-recyclable plastic waste challenges and enhance road pavement performance. The research outcomes have the potential to guide future road construction endeavors in a more environmentally conscious and effective manner.

Keywords: Plastic modified asphalt concrete; Non-recyclable waste plastic, Road construction, Waste management, Sustainability

.

ICSBE 2023-228

EXPLORING URBAN WALKABILITY: AN ASSESSMENT OF SIDEWALKS AND PEDESTRIAN FACILITIES IN PUBLIC TRANSPORT DISTRICTS; IN ACCORDANCE WITH THE GREEN SL® RATING SYSTEM FOR SUSTAINABLE CITIES THE CASE OF PETTAH, SRI LANKA

S.R. Dharmasena[1*], K.D.S. Nimashi [1]

[1]University of Moratuwa, Katubedda, Moratuwa, Sri Lanka.

**Correspondence E-mail: shameen1990@gmail.com, TP: +8180-4818-7395*

Abstract: Within the realm of sustainable city development, Public Transport Districts (PTD) emerge as a crucial focal point, exerting a profound influence on the dynamics of urban spaces. Central to this consideration is the concept of walkability, which underscores the critical importance of optimizing sidewalks and pedestrian facilities to enhance pedestrian-centric and high-quality transport landscapes. The primary objective of this research is to develop a detailed walkability evaluation framework by examining the Green SL® Rating System for Sustainable Cities by the Green Building Council of Sri Lanka—a tool designed to recognize and foster sustainable urban development practices within Sri Lanka. Grasping the requirements set by the Green SL® Rating System for Sustainable Cities, the developed framework is centred around three primary walkability factors: 1) Design and Infrastructure, 2) Safety and Traffic Conditions, and 3) Proximity and Land Uses. For empirical insights, a case study was conducted in the public transport district of Pettah in Colombo, Sri Lanka—a bustling economic centre that integrates various public transportation services. This case study utilizes a qualitative analysis approach involving on-site observations and visual surveys, aiming to answer the central research question: "To what extent do the existing sidewalks and pedestrian facilities within public transport districts promote walkability?". The findings from the case study reveal a significant gap: despite favourable proximity and land use attributes, inadequacies in design, infrastructure, safety, and traffic conditions collectively contribute to suboptimal walkability conditions within the case study area, rendering these spaces less favourable for pedestrian activities. It is expected that the findings will provide guidelines for respected parties to increase the efficiency of walking and quality of pedestrian environments, ultimately resonating with the broader aspiration for sustainable cities.

Keywords: Walkability; Public Transport District; Sidewalks; Pedestrian Facilities; Sustainable Cities

ICSBE 2023-231

STUDY ON THE EFFECT OF JOINT THICKNESS ON COMPRESSIVE STRENGTH OF BLOCK MASONRY WALLS CONSTRUCTED WITH MANUFACTURED SAND MORTAR

P.L.L.T.D. Alwis[1*], D. Nanayakkara [1]

[1]Department of Civil Engineering, University of Moratuwa, Sri Lanka

**Correspondence E-mail: thisarudhanushka1997@gmail.com, TP: +94768474399*

Abstract: In the construction industry, value engineering and sustainability principles hold significant importance. Investigating viable alternatives during global crises, such as the current situation, is essential. The construction industry in Sri Lanka suffers from a shortage of skilled masons currently, leading to poor workmanship and high material consumption. In this study, the investigation was carried out to study the effect of joint thickness on the compressive strength of block masonry walls using an economical and eco-friendly mortar type. By optimizing the joint thickness, not only it is possible to enhance the quality of the brickwork, but it is also possible to reduce material consumption through sustain-able practices. This study thoroughly examines the correlation between the thickness of joints and the compressive strength of masonry walls. Experimental investigations aimed to construct prisms with cement blocks, river sand, and manufactured sand mortar. The experimental results show that masonry with 10 mm thick mortar has a higher strength than that of 15 mm or 20 mm thick mortar joints. The strength of the prism decreases as the joint thickness increases. It is recommended that an ideal joint thickness of 10 mm is suitable for block masonry walls. This study will evaluate the capability of manufactured sand as an alternative for river sand in mortar mix, emphasizing the impact of joint thick-ness on the compressive strength of masonry walls.

Keywords: Compressive strength; Joint thickness; Sustainability; Manufactured sand; River sand; Masonry prisms

ICSBE 2023-235

BALANCING APPROACH BETWEEN CONSTRUCTION INDUSTRY AND ENVIRONMENTAL PROTECTION

KNKR Kodithuwakku[1*]

[1]*Faculty of Law/University of Colombo.*

**Correspondence E-mail: nethmikawya69@gmail.com, TP: +94765362638*

Abstract: Super tall Skyscrapers and Mega tall Skyscrapers are the symbol of development of the country. All around the island it is possible to see ongoing construction sites. Construction comes from the word "construct". It includes industrial branch of manufacturing and trade related to building repairing, renovating, and maintaining infrastructures. Even though it makes significant contribution to the national economy there are several environmental impact from the Construction Industry as well as some restrictions to the Construction industry from the Environmental Law. There should be a balancing approach between Environmental protection and the Construction Industry. Relevant Laws are not implementing in a sustainable way to achieve the sustainable development goals. Main objective of this research is to identify issues regarding Construction Industry and aims to find lacunas of current legal system to environmental protection. The research concludes by providing recommendations and suggestions to eco-healthy and greenery future. This research follows a doctrinal methodology to provide the balancing approach to the sustainable development of the country.

Keywords: Construction; Environmental; Sustainable; Project; Procurement; Assessment

ICSBE 2023-245

A STUDY ON THE SENSE OF COMMUNITY AND BEHAVIOUR PATTERNS OF INHABITANTS IN NUGEGODA COMMERCIAL STREETS

M.A.G. Medonza[1*], M.G.P. Manelgama[1], J. Wijeundara[1]

[1]School Of Architecture, Sri Lanka Institute of Information Technology.

**Correspondence E-mail: gayashi1999@gmail.com, TP: +94773653998*

Abstract: Nugegoda is a rapidly urbanized and vibrant mixed-use city that offers a diverse range of goods, services, and public facilities. The research problem that motivates this study is the impact of commercial development along the main street, on the sense of community in the area, as well as the lack of gathering spaces within the area that further intensifies this issue. The study focused on how the built environment impacts the formation of a sense of community and human behaviour patterns. Through observational data collection and thematic analysis, the study revealed insights into the community dynamics of three selected spots that have developed a sense of community within the built environment of the street itself. The study reveals insights into the temporal nature of the area and the types of activities that occur during specific times, highlighting the importance of understanding these factors to better plan and design for the community. Additionally, the study identifies the impact of specific built environments on attracting inhabitants and enhancing their interaction and consequentially the quality of urban life. The study provides valuable insights into the challenges and opportunities for creating a sense of community in commercial streets and highlights the need for a well-planned built environment to enhance positive social interactions among inhabitants.

Keywords: Mixed-use; Sense of community; Built environment; Temporal nature; Human behaviour patterns

ICSBE 2023-264

UTILIZING MODULARIZATION TO ACHIEVE SUSTAINABLE CONSTRUCTION

P.T.P. Jayathunga[1], B. Edirisooriya[1], P.C.O. Fernando[1*], N. Herath[1], K.K. Jayasinghe[1*]

[1]International Construction Consortium (Pvt) Ltd, 70 S. De S. Jayasinghe Mawatha, Nugegoda.

**Correspondence E-mail: oshan.fernando@icc-construct.com, kavindu.jayasinghe@icc-construct.com*

TP: +94772369920, +94777499310

Abstract: In today's world, there is a growing recognition of the importance of environmental concerns and the need for more effective and eco-friendly building practices. As a result, sustainability has become a crucial factor in the construction industry. This article explores the use of modularization as a sustainable approach in construction projects and presents a case study as an example. From the outset, our team intended to integrate Prefabricated Prefinished Volumetric Construction PPVC) modules into the design of the villa. We meticulously examined each detail of the architectural, structural, and MEP aspects to ensure that efficiency was maximized while time, labor, and cost were minimized. The incorporation of modular technology has provided us with ample advantages, and we have seamlessly integrated these into our pioneering approach. Using PPVC drastically reduced the construction time since the modules were fabricated off-site. The module fabrication process was done simultaneously with the site preparation/foundation process so that the continuous supply of modules was possible during the on-site construction. We reduced the manpower requirement and involvement of sub-contractors. PPVC can improve productivity by up to 40% in terms of manpower and time savings, depending on the complexity of the projects. According to this study, the project has achieved significant success in reducing construction waste at all stages and has enhanced the overall efficiency of the building process. The project has effectively decreased its carbon footprint by utilizing modularization in various technical aspects. The case study demonstrates how modularization can be a practical and effective solution for addressing sustainability issues in the construction industry.

Keywords: Modular; PPVC; Sustainable; Efficient; BIM

ICSBE 2023-265

HIGHWAY SOLARISATION IN SRI LANKA: A GIS-BASED EVALUATION OF SOLAR ENERGY POTENTIAL ON THE SOUTHERN EXPRESSWAY

W.M.S.S. Dias [1*], W.B.M.R.S. Basnayaka [1]

[1]University of Peradeniya, Peradeniya, Sri Lanka.

**Correspondence E-mail: mihirdias@gmail.com, TP: +94779414936*

Abstract: Sri Lanka, with its equatorial location, receives abundant solar energy resources, ranging from 1,247 kWh/m² to 2,106 kWh/m² throughout the year. Despite this potential, the utilisation of solar energy has been narrowed to small-scale rooftop solar installations. Consequently, this study investigates the concept of 'highway solarisation,' which integrates solar photovoltaic (PV) technology into the highways, with solar panels placed along their paths to capture sunlight and generate electricity. The Southern Expressway in Sri Lanka emerges as an optimal candidate for this initiative owing to its heightened solar intensity and minimal shading. Thus, this research aims to analyse the feasibility of implementing high-way solarisation along the Southern Expressway, employing Geographic Information System (GIS). The study area covers a 200.5 km long expressway, extending from Kottawa to Mattala, accompanied by a 250 m buffer on both sides. Various datasets encompassing Photovoltaic Power Potential (PVOUT), Direct Normal Irradiation (DNI), Global Horizontal Irradiation (GHI), Digital Elevation Model (DEM), and land use were collected and processed using ArcGIS 10.8.2. Subsequent to the generation of maps delineating PVOUT, DNI, GHI, elevation, aspect, and land use, the Multicriteria Decision Making (MCDM) technique was employed to identify suitable sites for solar panel deployment. Analysis of PVOUT revealed a variation of 3.95-4.25 kWh/kWp while peak and lower values concentrated between 130-200 km and 40-111 km markers along the highway. Notably, the distribution of DNI exhibited similar trends, with a peak in proximity to the Mattala Interchange (IC). The GHI ranged from 5.05-5.50 kWh/m², with an upward trend from 130-200 km. Elevation and aspect profiles highlighted the predominantly flat terrain of the expressway, which increases the direct solar irradiation. Challenges were identified particularly from Kottawa to Kokmaduwa IC, notably in urbanised and densely vegetated areas. However, the open land cover segment beyond Kokmaduwa to Mattala IC in the Southern Expressway portrayed moderate to high suitability for solar panel installation, highlighting its substantial potential for highway solarisation and contributing to sustainable energy generation in Sri Lanka.

Keywords: Highway solarisation; The Southern Expressway; Solar energy; Geographic Information System (GIS)

ICSBE 2023-272

ANALYSING THE DAYLIGHT DISSEMINATION IN HIGH-RISE INTERIORS: A ZONE-SPECIFIC CASE STUDY AT SAINTGITS

C. Punnya Brahmanand [1,4], M. Dhanyasree [1,4], Sajan Thomas [2,4], Joselin Herbert [5], Jacob Thottathil Varghese [2,4*], Basil George Thomas [2,4], Arjun Venugopal [2,4], Siju K S [3,4]

[1]Department of Chemical Engineering, Saintgits College of Engineering (Autonomous), Kerala State, India

[2] Department of Mechanical Engineering, Saintgits College of Engineering (Autonomous), Kerala State, India

[3] Department of Mathematics, Saintgits College of Engineering (Autonomous), Kerala State, India

[4] APJ Abdul Kalam Technological University, Thiruvananthapuram, Kerala State, India

[5] Department of Mechanical Engineering, NICHE, Kumaracoil), Tamil Nadu State, India

**Correspondence E-mail: dr.jacobtvarghese@gmail.com, TP: +919500363276*

Abstract: Rapid urbanization has systematically lured the inhabitants to expend more on plentiful means to maintain decent levels of indoor occupant comfort. Greater levels of space constrain in built environments demand higher physical proximity among their built structures. Since the inflow of natural lighting is extremely dependent on the availability of hindrance-free regions at any geographical locale, it is appreciable to simulate, visualize, and quantify the amount of achievable indoor daylight. This piece of work involves zone-specific analysis that encompasses both experimental and architectural modelling to learn the dissemination of natural lighting at the sixth level of a nine-storied built structure at SAINTGITS, a prominent technological institution down south of the Indian subcontinent (9.5100°N, 76.5514°E). The analysis explores a set of design modifications, including fabric openings, internal partitions, and site orientations that can effortlessly ascertain the lowest levels of artificial lighting loads during the daytime. Furthermore, this work quantifies the illuminance level in terms of the attainable daylight factor (DF) at indoor regions: regions with DF > 2 are deemed adequately lit throughout the active hours of any normal day. This work provides a direct indicator to envisage and accomplish one of the seventeen Sustainable Development Goals (17 SDGs) of the United Nations: Sustainable Cities and Communities (SDG11).

Keywords: SAINTGITS; Daylight factor; High-rise structures; Sustainability; 17 SDGs; SDG11

ICSBE 2023-273

THE CURRENT GROWTH OF GREEN ENERGY AND ITS DEVELOPMENT IN INDIA

Er. Aditya Singh[1*]

[1]*Amrita Vishwa Vidyapeetham, Coimbatore, India*

**Correspondence E-mail: aditya7777777k@gmail.com, TP: +919872262374*

Abstract: Green Energy has become the norm of development in the world, with the increased environmental degradation and global warming problems over the past decades. At present, all developed, developing and underdeveloped countries are progressing towards the development of the green energy as much as possible. This paper particularly takes the case of India and highlights the current stand and policies of the government in regards to the Green Energy. The paper also covers the development of Green Energy so far in the country India and includes major projects in the country which are assisting its growth. Some research gaps were found after considering numerous scientific and research papers published over the years. Some graphical analysis will be performed from different sources in order to understand the trend and possible future growth of Green Energy in the country, to support the study.

Keywords: Green Energy; Sustainable Projects; India; Development; Solar Power

ICSBE 2023-343

THE EXPRESSION OF HOME AND ITS ARCHITECTURAL MANIFESTATION IN THE SRI LANKAN CONTEXT

D.M.C.S.Pieris[1*], J Wijesundara[1]

[1]Sri Lanka Institute of Information Technology School of Architecture

**Correspondence E-mail: shirunipieris@gmail.com, TP: +94766391721*

Abstract: Architecture serves as a central element in responding to the constantly shifting demands of humanity, all the while addressing the critical issues surrounding environmental sustainability. It encompasses all needs the man desires and expresses them through an architectural manifestation in society. Within a short period, Sri Lanka's socioeconomic structure underwent rapid urbanization. As the newly urbanized population attempted to adopt the lives and culture of the nouveau-rich, the close-knit society began to erode. Due to this, an eclectic style of residential architecture emerged that was not viable for the nation. The study, therefore, investigates the change in the expression of home and its architectural manifestation through an attempt to achieve the objectives that distinguish the concepts of home and house, the attributes of the expression of home observed in Sri Lanka, and architects' role in guiding them to a meaningful architectural manifestation. Understanding the deeper significance of these processes through research and reasoning might result in architectural manifestations that are more localized and authentic, thereby aiding purposeful and sustainable architecture. The study investigates literary data and Primary research through structured questionnaires to find new meanings for the word "home" in terms of theoretical notions of home. The study's findings could help architects develop meaningful architecture for society by guiding them in understanding the ways their clients perceive their idea of a home.

Keywords: Expression of Home; House; Architecture; Sri Lanka

ICSBE 2023-345

RESETTLEMENT STRATEGIES AND SUSTAINABLE DEVELOPMENT: A CASE STUDY OF THE MORAGOLLA HYDROPOWER PROJECT

N. W. Bulathge[1*], C K S Handagala [1], E M T K Ekanayake [2]

[1]REM, Moragolla Hydropower Project, Ceylon Electricity Board, Sri Lanka.

[2]YCP Engineering Solutions Pvt, Ltd, Sri Lanka

**Correspondence E-mail: bulathgenadun@gmail.com , TP: +94718124659*

Abstract: This paper, titled "Resettlement Strategies and Sustainable Development: A Case Study of the Moragolla Hydropower Project," explores the comprehensive approach taken by the project to address resettlement challenges and foster sustainable development. The Moragolla Hydropower Project (MHP), a key component of the Sri Lanka: Green Power Development and Energy Efficiency Improvement Investment Program, exemplifies how large-scale infrastructure projects can promote sustainability and social well-being. MHP's Entitlement Policy, encompassing the Resettlement Plan (RP), extends beyond compensation, emphasizing a Community Development Plan that uplifts household income, education, and social cohesion. Special focus is placed on empowering women and children through skill development and gender-specific training. The establishment of a Grievance Redress Mechanism (GRM) ensures transparency and dispute resolution, while dual monitoring mechanisms uphold accountability in the RP's execution. MHP stands as a model for responsible and sustainable development, emphasizing holistic well-being and sustainability, in alignment with the United Nations Sustainable Development Goals (SDGs). This case study of the Moragolla Hydropower Project illustrates a path forward for large-scale projects, demonstrating how they can contribute to both sustainable development and the welfare of affected individuals.

Keywords: Resettlement Strategies; Hydropower Project; Sustainable Development; Grievance Redress Mechanism; Socio-Economic Impacts

ICSBE 2023-354

MECHANICAL PROPERTIES OF GREEN CONCRETE CONTAINING POLYPROPYLENE PLASTIC WASTE

T. Abirami[1*], K. G. D. I. H. Thilakarathna[1], W. A. R. U. Weragama[1], C. S. Bandara[1], H. D. Yapa[1], P. B. R. Dissanayake[1]

[1]*Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Peradeniya, 20400, Sri Lanka*

**Correspondence E-mail: thuraisingamabirami@gmail.com, TP: +94769458597*

Abstract: The plastic aggregate concrete (PAC) can result in reducing natural resource extraction while reducing the cost and energy consumption of the plastic recycling process. According to previous studies, Polypropylene is the plastic type, having the highest demand but the lowest recycling percentage. Therefore, this study investigates the performance of incorporation of recycled polypropylene (PP) waste plastic as a partial replacement of natural coarse aggregate (NCA) in normal strength concrete. This study aims to evaluate the fresh and hardened properties of PAC including workability, fresh density, compressive strength, hardened density, and splitting tensile strength. The experimental work consists of varying percentages of PP aggregate (PPA) as volumetric replacement levels of 0%, 10%, 20% and 30% of the NCA. The results revealed that the workability and strength properties of concrete were negatively affected by PPA incorporation while a positive impact of 2%, 5% & 7.5% reduction in concrete density was achieved with 10%, 20% & 30% PP content, respectively. The microstructural analysis was carried out to authenticate the strength reduction in PAC. It clearly showed that the Interfacial transition zone (ITZ) between PPA and cement paste was weaker than that of NCA. The enhancement of workability in PAC was possible with the addition of high-range water-reducing superplasticizer (Plastobuild ES), whereas minor strength reduction was observed with the increasing admixture dosage levels. However, the concrete mix design satisfied the expected compressive strength limits of normal strength structural concrete up to 30% PP replacement level. Thus, it is suggested to use PPA up to 30% for structural concrete with further inspection on the influences of the various types of admixtures on the performance of PAC, structural performance and durability properties.

Keywords: Polypropylene waste plastic; Coarse aggregate; Mechanical properties; Compressive Strength; Workability

ICSBE 2023-356

HOW GREEN IS WORLD'S GREENEST CITY?

Şerban Procheş
University of KwaZulu-Natal
South Africa
**Correspondence E-mail: prochess@ukzn.ac.za*

Abstract: Durban, a city of over 3 million people, located on South Africa's Indian Ocean coastline, was chosen in 2019 by Husqvarna as world's greenest city, primarily on the basis of its large, interconnected network of green spaces, known as D'MOSS (Durban Metropolitan Open Space System). This consists of formal conservation areas as well as other spaces and corridors, with vegetation fitting in at different levels along the continuum between natural and anthropogenic. There are also various degrees of green space utilization by Durban's population, living in formal and informal settlements with varying income levels. Here I discuss how this open space system defines and serves Durban's biodiversity and ecosystem function, and to what extent its greenery meets contemporary conservation best practices. I conclude that, despite numerous challenges and limited law enforcement, Durban has one of world's most spectacular urban biodiversity landscapes, and can serve, if not as an outright model, then certainly as a useful set of lessons in urban green space planning and management.

Keywords : Biological Invasions; Habitat connectivity; Urban biodiversity; Urban greening; Urban wildlife

SUSTAINABLE CONSTRUCTION WITH HEMP – TOWARDS NET ZERO 2050

Chathushika Ekanayake[1*], Priyan Mendis[2], Shiromal Fernando[3], Massoud Sofi[2]

[1] Department of Civil Engineering, University of Moratuwa, 10400 Sri Lanka

[2] Department of Infrastructure Engineering, The University of Melbourne, Victoria 3010 Australia

[3]Civil and Structural Engineering Consultants (Pvt) Ltd, Sri Lanka

[*] Corresponding author; emjcekanayake@gmail.com

Abstract: COP 28 summit demands immediate pursuit in global climate action and in the imperative transition to sustainable construction practices, particularly the aiming to achieve net-zero carbon emissions by 2050. This paper explores the significant potential of incorporating hemp-based materials in construction as a key strategy to pursue sustainable construction. Hemp, emerges as a sustainable, carbon neutral alternative with the capacity to revolutionize traditional construction methodologies. The carbon sequestration ability, low environmental impact, energy-efficiency, applicability in construction applications, biodegradability and recyclability of hemp-based materials, coupled with its support for regenerative agricultural practices, position hemp as a viable solution. As the construction industry strives for a greener future, the integration of hemp aligns with broader sustainability objectives and represents a crucial step towards achieving net-zero carbon emissions by 2050.

Keywords: Hemp, Hempcrete, Carbon sequestration, Carbon neutral, Life Cycle Assessment

SECRA/ FOUNTAIN

ICSBE 2023-283

INVESTIGATING HOW GREEN INFRASTRUCTURE AFFECTS PARTICULATE MATTER CONCENTRATIONS IN URBAN STREET ENVIRONMENTS

H.A.T.N. Perera[1*], K.G.N.H. Weerasinghe[2], R.U. Halwatura[2], G.Y. Jayasinghe [1]

[1]Department of Agriculture Engineering and Environmental Technology, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka.

[2]Department of Civil Engineering, University of Moratuwa, Katubadda, Sri Lanka

**Correspondence E-mail: hatnperera@gmail.com , TP: +94766104399*

Abstract: Air pollution is a significant problem that requires action. Despite efforts to reduce its impact, long-term damage has occurred. The main source of air pollutants is transportation. Annually, automotive engines produce around 11% of local fine particulate matter and 28% of nitrogen oxide production. Particulate matter (PM) has a substantial direct and indirect environmental impact. This study recommends the construction of vegetation barriers of specific lengths to address this issue. It also establishes acceptable air quality standards for infrastructure projects. The Kandy district was chosen as the study area due to its potential for high air pollution. The selection of data was based on three factors: air quality, distance from main roads, and vegetation/barrier structure. Various plant species and barrier designs were examined at 20 sites near main roads in the Kandy district. On-site data collection for particulate matter was conducted between 9 am and 12 pm, at a height of 1 meter above the ground, every 5 meters from the road towards the vegetation cover. The impact of flowering/pollination on particulate matter was only evaluated for fruit plantations. Data analysis and interpretation were performed using Microsoft Excel, following the WHO air quality guidelines from 2020. Conclusions were drawn by summarizing the findings from the 20 sites. The roadside pollution scenario showed variations in $PM_{1.0} < PM_{2.5} < PM_{10}$, measured in $\mu g/m^3$. To meet the threshold levels for all PM contaminants on the road, it is recommended to install vegetation barriers of 100 to 150 meters in length. The combination of "fruit plantations" (*Nephelium lappaceum, Mangifera indica, Psidium guajava, and Musa paradisiaca*) and "Mara-tree cover" (*Delonix regia*) is suggested as the most effective vegetation barrier. Improved tree coverings offer additional benefits for improving air quality and mitigating climate change, making them suitable for urban planning purposes.

Keywords: Air quality degradation; Building establishment; Green infrastructure; Particulate matter; Threshold levels

ICSBE 2023-291

REVISITING LAND USE PLANNING POLICIES FOR RIVERBANK SETTLEMENTS: LESSONS FROM MELAMCHI FLOOD IN NEPAL

Sanjaya Uprety[1*], Barsha Shrestha[1]

[1]Department of Architecture, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal.

**Correspondence E-mail: suprety@ioe.edu.np, TP: +977-9841731034*

Abstract: On June 15, 2021, Melamchi municipality in the Sindhupalchok district of Nepal was struck by a flash flood and debris flow, resulting in over 30 fatalities and numerous injuries. This calamity stands as one of the deadliest disasters in recent history. Seven out of 13 wards were affected, impacting 64% of the municipal population. The flood devastated agricultural land, leading to 686 households losing 95.76 hectares, transformed into sand due to the floodwaters. This study aims to overview the causes and repercussions of the flood, assess the local authorities' response to the disaster, and examine the proposed resettlement policies for affected households. The study used a mixed-methods approach involving field observations, interviews with key informants, and focus group discussions with stakeholders, including municipal representatives. The findings reveal that extreme rainfall events in the river catchment area, likely linked to climate change, were the primary cause of the disaster. The debris, reaching up to 16 meters in some areas, inflicted substantial damage to agricultural and urban lands, including built infrastructure. Initially, the proposed resettlement policy, involving forced relocation, failed due to the lack of community involvement in decision-making. Nonetheless, the study indicates that the community embraced a risk-sensitive land-use plan offering multiple relocation options. These included immediate rehabilitation of three affected bazaar areas, dredging the filled riverbed to restore lost agricultural land, and resettlement choices in nearby risk-free land developed through land pooling. The study concludes that resettlement policies, considering community participation, inclusion of their concerns and preferences, and providing voluntary relocation choices, are keys for successful resettlement in riverbank settlements. These findings hold significance for policymakers, disaster management practitioners, and community leaders, aiding in the development of effective disaster risk reduction strategies and policies.

Keywords: Land use planning; Policies; Resettlement; Risk sensitive land use

ICSBE 2023-297

SPATIAL AND TEMPORAL VARIABILITY OF RAINFALL TRENDS TO INDICATE THE CLIMATE CHANGE AND EXTREME WEATHER EVENTS FOR PAST THREE DECADES – A STUDY IN GALLE DISTRICT FROM 1992 TO 2022

P L C Perera[1*], M Ranagalage[2], G Y Jayasinghe[1]

[1]Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna, Sri Lanka

[2]Department of Environmental Management, Faculty of Social Sciences and Humanities, Rajarata University of SriLanka

**Correspondence E-mail: lakmiperera04@gmail.com, TP: +94763705037*

Abstract: Analysis of long-term rainfall trends and their variability provide valuable information to prove climate change and meteorological disasters. Galle district has indicated several extreme weather events during past few decades. But there is lack of investigation on rainfall with rainy days using non-conventional methods. Therefore this study reveals spatial and temporal variability of rainfall between 1992 and 2022 in the Galle district of Sri Lanka. The study was based on monthly rainfall and the number of rainy days in four weather stations over the Galle district. Using Microsoft Excel, R studio data and ArcMap 10.3.1 were selected to analyze data. The predictive mean matching method was employed for filling in missing values to avoid quality issues. Mann-Kendall test with Sen's slope estimator, Standard Precipitation Index, and Inverse Distance Weighting are the methods that are used to find rainfall trends, wet and dry conditions, and spatial variability respectively. The highest annual rainfall (5251.80 mm) and number of rainy days (233 days) were recorded in Baddegama. October and May, South West Monsoon, and 1993 were the wettest months, seasons, and the year. 2020 has indicated the highest number of dry days for study period. Baddegama had the highest increasing upward trend for rainfall. According to SPI 3,6,12, the year has higher risk of drought and flood were 1995 and 2020. Therefore, this study is advisable to prepare adaptation and mitigation policies and drought and flood management systems for the vulnerable areas.

Keywords: Drought Analysis; Mann-Kendall test; Rainy days; Sen's Slope Estimator; SPI

ICSBE 2023-300

AN ASSESSMENT OF ENTREPRENEURIAL RESILIENCE AMONG WOMEN ENTREPRENEURS IN SRI LANKA

D.P.Lokuwithana[1*], K.Hemachandra[2], P.B.R.Dissanayake [3]

[1]gap Headquarters, Colombo 07.

[2]University of Huddersfield, UK.

[3]University of Peradeniya, Peradeniya.

**dilshani.prathibha97@gmail.com, TP: +94710957076*

Abstract: This paper explores the resilience of women entrepreneurs in Sri Lanka during the pandemic and economic crisis. In a country with a population of approximately 22 million, where 52% are women. Nevertheless, women's participation in the labour force is quite low, with only 34% of the 8.5 million economically engaged individuals. Furthermore, only 17% of women are early-stage entrepreneurs, and 14% are established business owners. Traditionally, women entrepreneurs face a multitude of challenges, including societal norms, limited access to financial resources, lack of education, cultural limitations, and the balancing of family and business responsibilities etc. The onset of the COVID-19 pandemic exacerbated these challenges, resulting in a significant and disproportionate decrease in the number of women starting or sustaining businesses compared to their male counterparts. Notably, increased family responsibilities during the crisis played a pivotal role in this decline. This existing literature highlights the multifaceted challenges and experiences of women entrepreneurs during this pandemic. Additionally, the paper aims to identify the initiatives, community support networks, and innovative business strategies that emerged during this pandemic by conducting a literature review to formulate effective solutions for future crises while promoting resilience among women entrepreneurs.

Keywords: Woman Entrepreneurs; COVID-19; Challenges; Entrepreneurial resilience; Enablers

ICSBE 2023-302

FINANCIAL INSTITUTIONS' READINESS TO SUPPORT SMES AMIDST THE ECONOMIC CRISIS - PERCEPTIONS OF GROUND-LEVEL OFFICERS: A CASE STUDY FROM SRI LANKA

S.M.S.N. Senanayake[1*], P.A.N.P. Pandipperuma[2], J.M.H.M. Upulwehera[1], P.B.R. Dissanayake[3], R.P.I.R. Prasanna[1]

[1] Faculty of Social Sciences and Humanities, Rajarata University of Sri Lanka,
[2]Postgraduate Institute of Agriculture, University of Peradeniya
[3]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya
**Correspondence E-mail: sadeeshasenanayake1995@gmail.com TP: +940701249883*

Abstract: SMEs are considered the backbone of economies worldwide, with their immense contribution to economic development. The Sri Lankan economy was disrupted during the economic recession followed by the COVID-19 pandemic, and thus, the SME sector has been facing significant vulnerabilities. The researchers aimed to reveal the financial challenges of SMEs as a solution to overcome the aforementioned obstacles using qualitative data gathered from a sample of ten ground-level employees working in financial institutions. Following an in-depth thematic analysis, the researchers defined four main themes as follows: paying salaries & wages of employees, adopting and maintaining ethical business practices, gaining access to relevant business financing stages, and adopting new technologies. These were identified as key occasions where SMEs need financial assistance from institutions during an economic crisis. Findings revealed that institutions are already providing a variety of services, including loan programs favorable for SMEs. However, personal guarantees, strong business plans, CRIB reports, and age restrictions are the major obstacles that demotivate SMEs from applying for those. The study emphasized some key defects of the institutional setting, such as the unavailability of financial support for some specific challenges SMEs face, the unawareness of officers about SMEs' specific needs, and strict requirements when applying for a loan. Thus, it highlighted the importance of making SMEs aware of the legislative environment in financing and the importance of making laws and regulations more favorable for SMEs' needs from the institutional side. The study further emphasized the importance of maintaining a single financial policy and coordination among financial institutions to improve the quality of the services provided. Institutions should be more specific in services provided to offer SMEs effective solutions to overcome the financial challenges in the economic crisis. These findings are significant to policymakers and other interested parties to make timely decisions related to enhancing SMEs' survivability.

Keywords: Economic crisis in Sri Lanka; Financial institutions; Financial challenges; SMEs; SME survivability

ICSBE 2023-303

THE IMPACT OF CLIMATE CHANGE ON FOOD SECURITY: A REVIEW OF RECENT RESEARCH

W.G.M Randika*, S.M.T.P Suriyapperuma, G.Y. Jayasinghe

Department of Agricultural Engineering and Environmental Technology, Faculty of Agriculture, University of Ruhuna

*.*Correspondence E-mail:: randika4710@ags.ruh.ac.lk*

Abstract: The challenge of climate change has emerged as a paramount concern, poised to significantly impact global food security. This abstract considers recent research on the effects of climate change on food security, emphasizing its repercussions on crops, food prices, and overall food availability. The decline in output is mainly due to global warming, the unconventional nature of changes in precipitation levels and extreme weather incidents. The unpredictability of rainfall, status of the soil and pest and diseases also play an important part in determining the final result. These changes are expected to cause food shortages. Due to that, developing countries such as Sri Lanka face huge problems where smallholder farmers are heavily reliant on rain-fed agriculture. Research indicates that the shifting climate is likely to result in a decline in fish stocks which could have significant consequences for the millions of individuals who depend on fish as a vital protein source. The issue is predicted to worsen in the future due to increase population. The impact of climate change on food prices is also a concern as a secondary effect with research indicating that food prices are likely to increase due to supply shortages in the market. The anticipated outcome of this situation is poised to have a substantial impact on vulnerable communities especially those experiencing poverty as they may encounter difficulties in affording essential food items due to the low-income generation. Climate change could prompt alterations in individuals' production and consumption behaviours, potentially leading to decrease in calorie consumption. Consequently, this may have repercussions on crop yields, food prices, and overall food accessibility. Nevertheless, farmers are embracing adaptive measures that including the utilization of hybridized and genetically modified crop varieties as well as advancements in livestock production. These strategies have the potential to contribute positively to ensuring food security.

Key words: Climate change; Food security; Global warming; Population expansion; Poverty

ICSBE 2023-308

INNOVATION ECOSYSTEMS: SUSTAINING UNIVERSITY-INDUSTRY HARMONY IN THE ASIAN EDUCATIONAL LANDSCAPE

S.M.S.N. Senanayake[1*], T.S. Ukwatte[2], G. Y. Jayasinghe[2], P.A.N.P. Pandipperuma[3], J.M.H.M. Upulwehera[4], M.C. Karunadasa[2], K.M.C. Tharupath[2], P.B.R. Dissanayake[1], Lahiru N. Dissanayake[1], C. S. Bandara[1]

[1]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya
[2]Faculty of Agriculture, University of Ruhuna Sri Lanka
[3]Postgraduate Institute of Agriculture, University of Peradeniya
[4] Faculty of Social Sciences and Humanities, Rajarata University of Sri Lanka,
**Correspondence E-mail: sadeeshasenanayake1995@gmail.com TP: +940701249883*

Abstract: University-industry collaborations (UIC) are the intricate links formed between higher education institutions and industries that serve as catalysts for knowledge empowerment and technical advancement. The diverse structures of universities and enterprises, together with the difficulties inherent in harmonizing their interests, offer considerable barriers to forming long-term UIC programmes. Disparities in resources, a scarcity of human capital, and the lack of a coordinated innovation strategy appear as persistent barriers, particularly in the changing environment of Asian academics and business. The purpose of this research is to thoroughly investigate and analyze the problems that practitioners experience while conducting collaborative efforts in various worldwide contexts. Its major objective is to develop substantial recommendations to promote successful UIC in Asian institutions and enterprises. To do this, the research focuses on the constraints of international university-industry collaboration, with a particular emphasis on blended learning, interdisciplinary collaborative research, student employability, and techno-entrepreneurial abilities. The research conducts a comprehensive literature analysis to analyze key aspects important for strengthening collaboration between universities and enterprises. The findings go into further detail on the enabling variables that help minimize UIC implementation's observed limitations. Notably, the study highlights the potential advantages of academics collaborating with universities to gain access to employers for one-on-one interviews, thus improving our understanding of employability dynamics. In terms of education, the study argues for including Technopreneurship courses, particularly in research-based studies, journals, and seminars, to improve employability. Furthermore, the study's suggestions include strengthening the linkages between universities, enterprises, and research institutions in order to advance the development of invention, innovation, and entrepreneurship. This comprehensive strategy strives to connect the ambitions of graduates, academics, farmers, SMEs, and varied industries in Sri Lanka and beyond Asia. The study predicts a revolutionary influence on the collaborative environment as a result of these ideas, enabling a more sustainable and impactful future.

Keywords: Blended learning; Student employability; Sustainable partnerships; Technological innovation; Techno-Entrepreneurship; University-Industry harmony

STRUCTURAL ENGINEERING

ICSBE 2023-186

REUSABILITY OF CONCRETE STRUCTURAL ELEMENTS AFTER THE SERVICE LIFE – SRI LANKAN PERSPECTIVE

S.A.R.B.S. Siriwardhana[1], G. Tharmarajah [1*]

[1]Department of Civil Engineering, Sri Lanka Institute of Information Technology, New Kandy Road, Malabe, 10115, Sri Lanka.

**Correspondence E-mail: gobithas.t@sliit.lk , TP: +94725 900 200*

Abstract: Construction industry in Sri Lanka contributes to about 8- 10% of the GDP while construction of buildings contributes to about 43% of the total construction by value. Therefore, it is important to explore the possibility of re-using existing structures and designing future structures considering re-use of structural and non-structural elements. Reinforced concrete (RC) and masonry construction remains a popular construction method in Sri Lanka owing to the cost benefits and ease of construction. However, the country is yet to define a policy on demolition and disposal methods of reinforced concrete structures that either complete the service life or required demolition for reconstruction. Due to shortages in natural materials, there is a significant emphasis on reusing and recycling materials used in construction in many developed countries. As structures complete the service life, they either require an extension to the service life or require demolition. The structures that are to be demolished provide an opportunity for the stakeholders to reuse some of the structural elements at the end of their service life. Further, some elements can be recycled. Both recycling and re-use require a criterion according to which the processes can be carried out. It should be observed that any future designs using reinforced concrete elements can adopt a design philosophy that emphasizes re-use of structural elements. This paper discusses two aspects of re-usability of RC structures. The potential re-use of structural elements from the aging RC buildings analysed using stakeholder survey and field tests is presented in this paper. The study further discusses methods adopted in construction of reinforced concrete structures considering future re-use and its applicability within the Sri Lankan context to achieve sustainability goals.

ICSBE 2023-275

SUITABILITY ASSESSMENT OF COMPOSITE CROSSARMS

S Bandara[1*], P Rajeev [2], E Gad [2]

[1] University of Peradeniya, Peradeniya,20400, Sri Lanka

[2] Swinburne University of Technology, Melbourne,VIC 3122, Australia

**Correspondence E-mail: sahan@eng.pdn.ac.lk, TP: +94717450090*

Abstract: Crossarms are installed in suspension towers and utility poles to support overhead cables. These structures are extensively used in power distribution and telecommunication sectors. Timber is used as the conventional material for crossarms and as a biodegradable material, timber crossarms deteriorate over time mainly due to weathering, decay and termite attack. Therefore, this paper investigates the feasibility of composite crossarms for industrial usage considering the mechanical strength. A comprehensive experimental programme is conducted in accordance with Energy Network Association (ENA) guidelines to verify the compliance of composite crossarms. The primary mechanical tests carried out were average failing load test, sudden load release test, crush resistance test, bolted connection capacity test and evaluation of modulus of elasticity. Electrical tests and durability tests of composite crossarms are not within the scope of this study. Results of the mechanical tests are presented in this paper, and it indicates the superior performance of composite crossarms satisfying the requirements of the guidelines. Advantages of composite crossarms such as lower weight, low maintenance and installation cost, non-conductivity and improved resistance to environmental factors along with superior mechanical properties attest the suitability of composite crossarms to be used as power distribution infrastructure.

Keywords: Crossarms; Mechanical strength; Service life; Composites

ICSBE 2023-351

A FUZZY ANALYSIS APPROACH FOR EVALUATING THE INFLUENCE OF SUBJECTIVE APPRAISAL ON CONSTRUCTION PRODUCTIVITY DRIVERS

Amila Premakumara[1*], Isuri Amarasinghe [1], Chandana Siriwardana[2]

[1]Department of Infrastructure Engineering, The University of Melbourne, Australia

[2]School of Built Environment, Massey University, New Zealand

**Correspondence E-mail: apremakumara@student.unimelb.edu.au, TP: +61 (0) 468 858 861*

Abstract: Despite the ever-increasing technological advancements, the construction industry continues to be characterised by many inputs. In contrast, the industry is frequently susceptible to many distinct and severe external conditions, such as weather, economic factors, and social unrest. Often, these factors result in physical and mental distress in the workforce, eventually leading to low motivation and, as a result, low output and productivity. Numerous studies conducted over the years have yielded varying conclusions regarding the causes of low construction productivity conditions, based primarily on cross-sectional workforce surveys. Nonetheless, these studies have frequently neglected to evaluate the inherent fuzziness of human language in survey responses, particularly on qualitative measures. This study evaluates the impact of subjective evaluation of a construction workforce by analysing the responses of a survey conducted to evaluate factors affecting construction productivity in a developing country in South Asia. The methodology uses specifically derived fuzzy sets and inference principles mapping crisp values to fuzzy numbering and vice versa as defuzzification, thereby addressing the limitation above. The study's conclusions are supported by a comparative analysis of the frequency index, relative importance index (RII), and importance index (II). A clear distinction was observed when evaluating the significance of each element contributing to low construction productivity compared to the results obtained from defuzzified analysis. The findings of this study emphasise the need to include subjectivity assessment and readjusting analysis results to account for the inherent fuzziness of human language when assessing the construction industry. This paper also outlines the analytical approach of fuzzy analysis, using a distinct inference engine that assesses the collective influence of two or several factors on low construction productivity. Moreover, the methodology presents a flexible application in many sectors to comprehend subjective evaluation influence in cross-sectional response assessment.

Keywords: Fuzzy-analysis; construction-productivity; cross-sectional-survey; subjectivity; relative-importance-index

ICSBE 2023-352

FINITE ELEMENT MODELLING OF FATIGUE CRACK GROWTH OF CSH SUBJECTED TO CYCLIC FLEXURAL LOADING

S.Abeygunasekara[1*], J.C.P.H.Gamage [1], S.Fawzia [2]

[1]Department of Civil Engineering,Faculty of Engineering,University of Moratuwa,Sri Lanka.

[2]School of Civil and Envirenmental Engineering,Faculty of Engineering,Quensland University,Australia

**Correspondence E-mail: abeygunasekarasampath@gmail.com, TP: +94712227790*

Abstract: The Fatigue life of structural elements depends on a large number of internal and external factors. Such parameters could be broadly classified as geometry related, load related, Fiber material property related and environmental related factors. FEM is plays a vital role in analysis of structures. Mechanical behavior such as stress and strain of structural elements reflect effects of fatigue due to cyclic loads. Performance of CSH technique depends on a vast number of internal and external parameters which affects fatigue life of such structures. This study focuses on a nonlinear FEA at the CSH under cyclic flexural loads. The model geometry, material properties, boundary conditions and the finite element mesh are described in this investigation. Proposed model was solved with direct cyclic mode while the numerical technique was based on cyclic J-integral method dealing with EPFM approach. Numerical model results agreed with the laboratory test results too. A numerical model can be utilized to investigate invisible characteristics by the experiment. This model could be easily applied in real world applications to overcome expensive laboratory test procedures. The detailed numerical simulations conducted on the novel hybrid technique to control cracks of steel elements in civil engineering infrastructures. According to results from the FEM results cumulated the design guidelines for the CSH technique.

Keywords: CSH; CFRP; FEM; Crack

ICSBE 2023-353

COMPRESSIVE STRENGTH PREDICTION OF ULTRA-HIGH PERFORMANCE FIBRE REINFORCED CONCRETE (UHPFRC) USING ARTIFICIAL NEURAL NETWORKS

R.S.S.A. Wijesundara[1*], K.K. Wijesundara [1], N.M.S.H. Bandara [1]

[1]Faculty of Engineering, University of Peradeniya.

**Correspondence E-mail: sandaruw@eng.pdn.ac.lk, TP: +94712595563*

Abstract: Ultra-High Performance Fibre Reinforced Concrete (UHPFRC) is a cementitious composite which contains fibres, leading to superior mechanical properties. This research employs Artificial Neural Network (ANN) techniques to predict the compressive strength of UHPFRC. A comprehensive literature review was undertaken to collect mix design information from previous experimental studies, resulting in the formation of a database consisting of 200 data points. This study integrated the Multi-Layer Perceptron Neural Network (MLPNN) method, a commonly employed technique in Artificial Neural Networks, for comparable prediction tasks. The developed model consisted of 10 input parameters such as the amount of cement, fine aggregate, superplasticizer, supplementary cementitious materials, fillers, water-to-binder ratio, fibre type, volume of fibres, aspect ratio, and tensile strength of fibre. Only one hidden layer was employed in the model and the optimum number of neurons for this layer was determined by a systematic performance analysis. The database was divided into 80% training and 20 % testing data and complimented by k-fold cross validation to prevent overfitting. The final model exhibited the coefficient of determination (R^2) and mean squared error (MSE) values of 0.883 and 85.57 respectively for test data. The predicted and actual compressive strength values showed reasonable agreement with the exception of a few points where minor deviations were observed. Furthermore, a sensitivity analysis of parameters was undertaken to study the influence of each material parameter on the compressive strength of UHPFRC based on the weights assigned by the ANN model. This analysis showed that the water-to-binder ratio has the highest influence followed by fine aggregates and supplementary cementitious materials. Also, it was revealed that the amount of filler materials and the fibre type only had a minor effect on the compressive strength of UHPFRC.

Keywords: Compressive strength; UHPFRC; ANN; MLPNN; Sensitivity analysis

SUSTAINABLE AGRICULTURE

ICSBE 2023-52

DESIGN AND DEVELOPMENT OF A HEAVY-DUTY DRONE FOR PEST CONTROL AND NON-HEALTHY TREE IDENTIFICATION IN NUTMEG CULTIVATION IN THE CENTRAL PROVINCE OF SRI LANKA

J.K.R.L.Weerawardhana [1*], W.M.H.M.Aththnayaka [1], M.L.Rankothge [2]

[1]Faculty of Electrical and Electronic Engineering ,International College of Business &Tecnology,Kandy, Sri Lanka

[2]Faculty of Bio Medical Science ,International College of Business &Tecnology,Kandy, Sri Lanka,

**Correspondence E-mail: write.to.ravindu@gmail.com, TP: +94781755420*

Abstract: The rapid expansion of the agricultural sector necessitates effective and enduring solutions to combat pest infestation. This study presents an advanced heavy-duty drone design specifically tailored for pest control in nutmeg cultivation within Sri Lanka's Central Province. The suggested drone integrates state-of-the-art technologies to meet the unique demands of local nutmeg farmers. A robust frame capable of withstanding harsh weather conditions, a powerful propulsion system for extended flight durations, and a payload system for efficient pesticide administration constitute the core of the drone's design. To ensure precise and consistent chemical application in pest management, the drone incorporates a specialized spraying mechanism. Intelligent algorithms optimize spraying patterns, reducing chemical usage while maximizing efficacy. Thorough testing and validation during the development process guarantee the drone's dependability, accuracy, and safety. Real-world field tests conducted in Central Province nutmeg farms evaluate the drone's pest control effectiveness. This study's findings advance precision agriculture practices in nutmeg cultivation, promoting eco-friendly methods, cost reduction, and increased yield. The development of this heavy-duty drone exemplifies the potential of drone technology in the agricultural industry, specifically for pest control. The outcomes also offer valuable insights for policymakers, farmers, and drone manufacturers striving to enhance agricultural practices and address challenges within Sri Lanka's nutmeg sector.

Keywords: Agricultural; drones; pest control; nutmeg; heavy-duty

ICSBE 2023-65

CHARACTERISTICS OF ESSENTIAL OIL EXTRACTED FROM SPOUTED BED DRIED BLACK PEPPER

G.K. Jayatunga[1*], B.M.W.P.K. Amarasinghe [2]

[1]Institute of Technology University of Moratuwa, Diyagama, Homagama, Sri Lanka.

[2] Department of Chemical & Process Engineering, University of Moratuwa, Moratuwa, Sri Lnaka

**Correspondence E-mail: gayanij@itum.mrt.ac.lk, TP: +94777334650*

Abstract: This paper outlines the characteristics of the essential oil extracted from black pepper dried in a spouted bed. A lab-scale conventional spouted bed dryer was used to dry raw black pepper. Drying experiments were conducted at 1.43 m/s of air velocity and air temperatures ranging from 45 °C to 75 °C for 14 cm of stagnant bed height of raw black pepper samples. The essential oil of dried black pepper samples was extracted from hydro distillation. The essential oil yield of black pepper dried at different conditions was measured and the Gas Chromatography-Mass Spectrometry analysis identified the components available. Caryophyllene (14.79 %) and D limonene (13.72%) are the abundant sesquiterpene and monoterpene compounds in black pepper essential oil respectively. Analysis of variance was conducted to compare terpene concentrations, caryophyllene concentration, and essential oil yield at different drying conditions applied under the investigations. 65 °C drying air temperature provides consistent quality essential oil with a high percentage of caryophyllene. 65 °C is selected as the optimum temperature to dry black pepper to achieve a higher yield of essential oil without degrading large amounts of volatile components.

Keywords: Black pepper; Essential oil; Spouted bed; Drying

ICSBE 2023-84

EVALUATION OF ANTIMICROBIAL AND ANTIOXIDANT EFFECTS OF CHITOSAN-BASED EDIBLE, BIODEGRADABLE FILMS CONTAINING CINNAMON (*Cinnamomum zeylanicum*) ESSENTIAL OIL FOR FOOD PACKAGING

K.G. Kaushani[1], N.P. Katuwavila[2], R.A. Jayasinghe[3], A.H.L.R. Nilmini[1], G. Priyadarshana[1*]

[1]*Department of Materials and Mechanical Technology, Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka*

[2]*Department of Biomedical Science, Faculty of Science, NSBM Green University, Sri Lanka*

[3]*Department of Civil and Environmental Technology, Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka*

**Correspondence E-mail: gayanp@sjp.ac.lk, TP: +94713287738*

Abstract: The demand for eco-friendly packaging alternatives to traditional plastic packaging is increasing due to the need to reduce non-biodegradable waste and enhance food quality and safety. This study aimed to assess the antimicrobial and antioxidant properties of chitosan-based edible biodegradable films containing cinnamon (*Cinnamomum zeylanicum*) essential oil. The films were developed using a casting method, with varying concentrations (0.5%, 1%, and 1.5%) of cinnamon essential oil (CEO) as the active ingredient integrated into the film structure. The films underwent characterization and comparison to evaluate their physical, mechanical, optical, antioxidant, and antimicrobial properties and their soil biodegradability. The findings indicated that the higher concentrations of CEO led to the production of thicker films and a decrease in moisture content, ranging from 10.0% to 26.8%. The chitosan-based films incorporating CEO (Chn+CEO) demonstrated significantly ($p < 0.05$) enhanced water resistance (lower water solubility) compared to the films without CEO (Chn), primarily attributed to the hydrophobic nature of CEO. As the CEO concentration increased, the tensile strength of the films decreased while the elongation at break increased. Increasing the CEO concentration in the films resulted in a decrease in their soil biodegradability over 28 days. A higher concentration of CEO resulted in a significant ($p < 0.05$) increase in the total color difference (ΔE) and a significant ($p < 0.05$) decrease in the whiteness index. The Chn+CEO films demonstrated superior antimicrobial activity against both Gram-positive (*Staphylococcus aureus* and *Bacillus cereus*) and Gram-negative bacteria (*Klebsiella pneumoniae* and *Escherichia coli*), where 1.5% CEO inclusion showed the highest antimicrobial effectiveness. The antioxidant activity of the films increased with increasing CEO concentration, with IC_{50} values of 0.62, 0.29, and 0.22 mg/mL, respectively, for 0.5%, 1%, and 1.5% CEO concentrations. These findings imply that the developed chitosan-based films fabricated with CEO can serve as novel eco-friendly active materials in the food packaging sector.

Keywords: Antimicrobial; Antioxidant; Chitosan; Cinnamon oil; Edible packaging

ICSBE 2023-217

SMALL-SCALE FISH PROCESSING ESTABLISHMENTS AND THEIR VULNERABILITY TO CLIMATE HAZARDS

W.B.G.S. Welihinda [1*], D.A.M. De Silva [1]

[1]Department of Agribusiness Management, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka, Belihuloya.

**Correspondence E-mail: : geshaniwelihinda@gmail.com, TP: +94711821787*

Abstract: Small-scale fish processing establishments play a crucial role in the livelihoods of coastal communities. Dried fish and Maldives fish processors are the main contributors to Sri Lankan processed fish market. The main focus of this study was to identify the vulnerability of small-scale fish processors to climate-induced hazards and their adaptive capacity. Case studies were conducted in Matara and Hambantota districts and the 38 fish processing establishments were considered for data collection. A structured questionnaire, interviews, 2 focus group discussions, and field observations were key data collection tools. All fish processing establishments were managed by a female member of the fishing households, business is managed as a family business. Access to raw material, and acquiring second-grade fresh fish, was the main responsibility of the male members of the family. Fish processing operations were managed by the female members of the family who are playing various roles. Seasonal rainfall patterns, the intensity of rainfall, and market demand for fresh fish heavily affected on volume processed, quality of processed fish, and income generated. High vulnerability to climate-induced hazards, limited intervention strategies, and low adaptive capacity were identified as the main barriers to the fish processing establishments in the South of Sri Lanka. Production capacity; availability of raw materials, types and price of fish, ability to sun drying, and shelf life depend on the behavior of the South-West monsoons. Business continuity and tackling climate-induced hazards in the fish processing industry. The results show that storms and seasonal rainfall patterns have an intense vulnerability on fish processing establishments. Dried fish processing has a more severe effect on climate-induced hazards than Maldives fish processors. Adaptation measures like smoked drying, proper storing facilities, and constructing climate-resilient infrastructure can be taken to mitigate the impacts of climate change on the fish processing establishments in Sri Lanka.

Keywords: Adaptive capacity; Climate change; Fish processing; Vulnerability

ICSBE 2023-219

GREEN FINANCING AS A MEASURE TO BUILD RESILIENCE AMONG FISHERIES COMMUNITIES IN SRI LANKA

M.M.S.C. Senevirathne[1*], D.A.M. De Silva [1], M.Esham[1], C.N. Pupulawaththa[1]

[1]Department of Agribusiness Management, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka,Belihuloya, Sri Lanka

**Correspondence E-mail: cssulochana9@gmail.com , TP: +94713631454*

Abstract: Perceived impact of climate change on small scale fisheries, especially on people dependent on fisheries industry reached to the alarming levels. Adaptation strategies varied with availability and access to the resources. Climate change, disasters and vulnerability of fishing communities created a big picture globally while institutional stakeholders were able to design various intervention strategies to manage the situation globally. To cope with the effects of climate change, people dependent on fisheries have adopted several adaptation strategies. Present study focused to explore the access, availability and affordability of financial instruments to facilitate the coping strategies in resilience building of fishery value chains. Secondly, find out the structure and functions of the institutional landscape of the green finance and its governance mechanism was considered. Systematic literature review was instrumental in developing the conceptual framework on green financing in global and local context. Expert consultations and in-depth interviews with, officers of Central Bank, financial institutes, Ministry of Fisheries, Ministry of Environment, exporters, Non-Government Organizations (NGOs), fisheries cooperatives and community organizations were used to identify the institutional landscape of the green financing on fisheries sector. Focus group interviews were conducted with mixed group of fisheries industry stakeholders to obtain the availability, access and affordability of green finance in resilience building. Institutional landscape comprised of central government, international donor agencies, ministry of fisheries, NGOs, financial institutions, cooperatives and community organizations as the key players. The main types of financial instruments were grants, insurance schemes, pension schemes and concessional loan schemes. Results highlighted that private, public, and international aid projects mainly provided financing options for infrastructure development and community empowerment in coastal areas. Public investment on construction of coastal protective structures; coral reef and mangrove growing, revetments, offshore breakwaters, gori-ness, rock beddings, integrated hard coastal protective techniques established to mitigate the coastal erosion and facilitate the fisheries industry and this is identified as key climate financing option.

Keywords: Climate financing; Fisheries industry, Resilience; Adaptive strategy

ICSBE 2023-220

BUSINESS CONTINUATION MECHANISM FOR TEA SMALLHOLDERS: BUILDING RESILIENCE ON CLIMATE-INDUCED DISASTERS

M.G.D.N.M. Wijerathne[1*], D.A.M. De Silva1[1]

[1]Department of Agribusiness Management, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka, Belihuloya.

**Correspondence E-mail: mgdnmwijerathne@std.agri.sab.ac.lk, TP: +94765538067*

Abstract: Smallholder tea plantations are extremely important to the socioeconomic structure of many areas since they support innumerable farming groups as well as the economy. Tea smallholder's business performance, productivity, and returns were critically affected by the climate-induced disasters and associated problems. Labor shortage, high labor, and fertilizer prices triggered high costs of production, declined returns, and disaster risk increasing the socio-economic vulnerability of the communities that depended on smallholder tea plantations. The present study focused on investigating the vulnerability to climate change and induced disasters, identifying existing community-based resilience mechanisms, and developing participatory disaster risk reduction mechanisms for smallholder tea plantations. A stratified random sampling method was employed to gather data from a diverse range of 40 smallholder tea plantations in the Rathnapura and Matara districts of Sri Lanka. Expert consultation with the participation of researchers, public administrators, industry experts, officials from the Sri Lanka tea board, and NGOs was instrumental in developing the context of climate change-induced disasters, the vulnerability profile of tea smallholders, and community-based resilient building mechanisms. A field survey was conducted through a structured questionnaire and participatory approaches; mapping, resource inventory, and focus group discussions. Results revealed that tea small holders are highly vulnerable to climate-induced disasters; high-intensity rainfall, floods, landslides, unpredicted rainy seasons, soil erosion, and consequences on tea leaf production. Lack of industry-specific disaster preparedness, limited availability of climate financial instruments for resilience building, and less attention to local and indigenous knowledge on early warning, disaster preparedness was mainly affected by vulnerability. GIS-based participatory disaster risk reduction mechanism will help to bridge the existing gaps.

Keywords: Building resilience; Climate change; Small holders; Tea plantations; Vulnerability

ICSBE 2023-254

SUSTAINABLE TEA PLANTATION: A STUDY CONDUCTED ON THE SUSTAINLE STRATEGIES UNDERTAKEN TO OVERCOME THE IMPACT OF ECONOMIC RECESSION IN WELIMADA TEA ESTATES

N. M. S. U. Nissanka

Haritha Design, Welimada

**Correspondence E-mail: sanduninissanka5@gmail.com, TP: 0767983000*

Abstract: This research focuses on the impact of the ongoing economic crisis in Sri Lanka on the sustainable development of tea estates, particularly in the Welimada region, where the tea industry plays a crucial role in the economy. Given the economic challenges faced by the country, the study suggests that promoting the exportation of tea could be a viable solution to alleviate the crisis. The research emphasizes the importance of integrating environmental sustainability practices in the tea industry to reduce the carbon footprint, lower emissions, restore forest cover, and improve climate conditions. The objectives of the research include identifying how the economic crisis has affected the sustainable development of tea estates and examining the positive relationship between sustainable development and factors such as renewable energy, water management, natural fertilizers, and agroforestry preservation. The study adopts a deductive research approach and a positivist philosophy, utilizing a quantitative research method with data collected from 80 samples in the Welimada tea estates through a survey. The analysis, conducted using the SPSS tool, includes assessing the reliability of variables through Cronbach Alpha values and measuring the correlation coefficient to determine the strength of independent variables about the dependent variable. The research concludes with tested hypotheses and recommendations aimed at overcoming challenges faced during the economic crisis, promoting sustainable practices in tea estates, and contributing to environmental conservation.

Keywords: Sustainability; Welimada; Renewable; Energy; Water

ICSBE 2023-358

DEVELOPMENT OF LIGHTWEIGHT EXPANDED CLAY AGGREGATES FORMED USING SLUDGE DISCHARGED FROM THE DRINKING WATER TREATMENT PROCESS

Sajani H. Kolambage[1], Dimalka R.M.N[1], Chathura Sanjeewa W.G[2], Pradeep Gajanayake[1]*,

[1]Department of Biosystems Technology, Faculty of Technology, University of Sri Jayewardenepura, Pitipana, Homagama, Sri Lanka.

[2]National Water Supply and Drainage Board, Regional Support Center (Uva), Badulla, Sri Lanka

**Correspondence E-mail: pradeepgajanayake@sjp.ac.lk ;TP:* +94771522444

Abstract: Water treatment processes generate substantial sludge, presenting disposal challenges. This study explores repurposing sludge from the Demodara water treatment plant in Sri Lanka to create LECA. The nutrient-rich sludge is characterized, and its potential for LECA production is investigated. Employing a comprehensive methodology involving raw water analysis, sludge characterization, and pot experiments with chili plants using various potting media formulations, the research demonstrates the feasibility of converting water treatment sludge into LECA. Incorporating LECA into potting media enhances plant growth, showcasing economic and environmental benefits in transforming sludge into value-added products for sustainable waste management. The resulting sludge, rich in nutrients NPK and micro-nutrients, proves advantageous for soil enhancement. Evaluating six potting media treatments on chili (MICH HY1) growth under a completely randomized design, the study identifies treatment 05 (LECA + Soil mixture + Synthetic fertilizer (12:12:12)) as optimal, emphasizing the successful production and utilization of LECA from water treatment plants for enhanced potting media.

Keywords: Lightweight expanded clay aggregates; Water treatment plant; Sludge treatment; Potting media

FIRE SAFETY ENGINEERING

ICSBE 2023-36

REVIEW OF FIRE RESCUE RESOURCES AND PUBLIC AWARENESS ON THE FIRE SAFETY OF HIGH-RISE BUILDINGS IN SRI LANKA

THTN Premanath[1]*, KMC Konthesingha[1], IR Upasiri[1], HMSC Rathnasiri[1], WPHP Weerasinghe[1]

[1]Department of Civil Engineering, University of Sri Jayewardenepura, Rawathawaththa Road Moratuwa, Sri Lanka.

**Correspondence E-mail: thenupremanath@gmail.com, TP: +94763698515*

Abstract: Maintaining fire safety in high-rise buildings is paramount, considering the challenges of evacuating occupants and controlling fires. Globally, fire hazards result in almost 1% of annual GDP losses. Moreover, past researches have emphasised that building occupants should have a proper idea of how to evacuate, and the fire brigade should have enough resources and better operational practices to control a fire particularly in high-rise buildings. Consequently, most countries prioritise the fire safety of high-rise buildings. With the recent changes to Sri Lanka's skyline with the number of high rises from 7 to 130 from 2006 to 2020, it is crucial to examine the fire safety protocols of high-rise buildings in Sri Lanka compared to international standards such as National Fire Protection Association (NFPA). A document review and questionary survey were conducted to evaluate the adequacy of fire rescue resources and public awareness of high-rise building fires. An exponential growth of the high-rise building population in the Colombo Municipal Council (CMC) is identified. The study reveals that, although the number of fire stations for the CMC area is adequate with the international standards, the available resources in the Colombo fire service department are only adequate to extinguish a single high-rise building fire in one instance, not adequate for two or more simultaneous fires. Further, it was found that although people have an acceptable level of awareness of conventional active fire safety practices, 25% - 40% of the sample were unaware of the standard fire practices such as fire drills, refuge floors, voice evacuation and fire rat-ed doors. The requirement of uplifting the fire and rescue resources required in high-rise building perspective currently available in the fire service department, is hence emerged. The identified lagging aspects of public awareness of fire safety measures also needed to be upgraded.

Keywords: Fire safety; Highrise buildings; Fire safety regulations; Fire rescue resources; Public awareness

ICSBE 2023-284

INVESTIGATE THE THERMAL RESPONSE OF DIFFERENT INSTALLATION FORMS OF GLASS PANELS UNDER FIRE LOADING: A NUMERICAL APPROACH

R. G. S. S. Perera[1*], J. H. A Ruwanmali[1], T. Thevega[1], J. A. S. C. Jayasinghe[1]

[1]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Sri Lanka.

** Correspondence E-mail: e16278@eng.pdn.ac.lk, TP: +94712739159*

Abstract: Nowadays, non-load bearing walls are mostly used in high rise buildings due to the cost effectiveness as well as fast installation. But these walls are critical elements that can cause severe damage in buildings during a fire mainly due to the combustible materials. Therefore, selecting materials with strong heat resistant properties is important to reduce the fire risks. Glass is often selected material for non-load bearing external walls due to its transparency, affordability, availability, and sustainability. However, glass panels can be vulnerable to damage when exposed to heat loading due to their natural fragility. According to that, the method of installation is a main considerable factor when considering their susceptibility of failure. This applies to different types of shading methods and constraining conditions. Therefore, this study is conducted to investigate the thermal response of different installation forms of glass panels under fire loadings using numerical analysis, specially focusing on assessing the thermal behaviour of single glass facades subjected to fire loads with different installation configuration through the utilization of ABAQUS finite element software. There are three types of the glass facades according to the support condition; point supported, frame supported, and full glass curtain walls. Additionally, glass curtain walls can be further classified into fully exposed, horizontally hidden, vertically hidden, and fully hidden framing according to the method of frame installation. However, limited research has been conducted on the thermal response of frame-supported glass facades under varying shading and constraining conditions. For that, nine cases with different shaded and constraining conditions are modeled. The findings from the analysis indicate that there is a minimal impact on the temperature variation of glass façade due to the shading and constraint conditions. However, when increasing number of constraint edges of glass facade, breaking time increases which is safe result. This suggests that the edge-constrained glass panes are relatively safer than other glass panels.

Keywords: Brittle crack model; Constraint conditions; Finite element analysis; Glass fa-cades; Thermal loads

ICSBE 2023-287

HIDDEN DANGERS OF FIRE SAFETY IN MODULAR CONSTRUCTIONS

R.L.P. Godakandage [1,2*], K. T. Q. Nguyen[2], T.G.P.L Weerasinghe[1], J.C.P.H. Gamage[1]

[1]Department of Civil Engineering, University of Moratuwa, Sri Lanka

[2]School of Engineering, RMIT University, Australia

**Correspondence E-mail: godakandagerlp.21@uom.lk, TP: +94755342341*

Abstract: In light of increased attention to fire spread through cavity spaces, continuous cavity systems (vertical/horizontal) in Modular Constructions have been reported to participate in rapid fire spread. In the absence of in-depth published knowledge on fire safety concerns associated with these intermodular cavities, it was attempted to derive fire safety concerns for the intermodular cavities based on the behaviour of cavity fires in other similar cavity geometries. It has been identified that significant fire safety issues can be hidden under the various modular construction practices, which could be disastrous. Several fire scenarios were identified that could lead to fire entering intermodular cavity spaces. Once fire enters cavities, fire spreading through the intermodular cavities can result in loss of compartmentation in several ways. Under this fire spread, severe fire damages could occur as structural systems could also be affected, putting firefighters and occupants in danger due to the likelihood of sequential failure and contamination of smoke. Special attention is needed on the effectiveness of cavity barriers used in intermodular cavity spaces, and testing methods are needed to be revised. These identified concerns are essential to modular developers, fire professionals, and research enthusiasts to revisit improving the fire safety of modular constructions.

Keywords: Modular Constructions; Intermodular cavity; Cavity fire spread; Smoke spread; Cavity barriers

ICSBE 2023-296

FIRE PERFORMANCE OF POLYMER IN COMPOSITE MATERIALS FOR BUILDING CLADDINGS: A NUMERICAL APPROACH

T. Thevega[1,2*], J. A. S. C. Jayasinghe [1], D. Robert [2], C. S. Bandara [1], E. Kandare [2], S. Setunge [2]

[1]Faculty of Engineering, University of Peradeniya, Sri Lanka.

[2]School of Engineering, RMIT University, VIC 3001, Australia.

**Correspondence E-mail: thevegat@pdn.ac.lk, TP: +61437652623*

Abstract: High-rise buildings pose unique challenges when it comes to fire safety, particularly regarding the fire performance of non-structural elements. Recent severe fire incidents in high-rise buildings have highlighted the need for suitable materials to cover large areas and ensure adequate fire resistance. One major factor contributing to the rapid spread of fires in high-rise buildings is the failure of external cladding materials. Investigations have identified the use of polymer materials within composite materials as a significant reason for the combustibility of these claddings. Therefore, the impact from the polymer material in terms of combustible behaviour needs to be investigated clearly. The peak heat release rate (pHRR) is a critical parameter of a material's combustibility. Various material parameters have been identified as significant factors influencing the peak heat release rate. To understand the impact of these material parameters, a parametric study can be conducted using experimental or numerical results. However, conducting experiments can be costly, time-consuming, and may not be environmentally sustainable. Therefore, numerical analysis is performed using computer fluid dynamic (CFD) software: Pyrosim. Based on the numerical results, statistical analysis is conducted following design of experiments (DoE) method in Minitab software. Among different polymer materials which are used as a part of composite materials in building claddings, rigid polyurethane (RPU) is selected for the parametric study as it has high thermal resistance compared to other polymers. Heat of combustion, heat of reaction, absorption coefficient and reference temperature are identified as major significant parameters on the pHRR of the rigid polyurethane polymer material. The study provides a thorough investigation of composite materials containing polymers under various fire scenarios through parametric studies using computational simulations, thus aiding in the design of fire-resistant non-structural elements for high-rise buildings.

Keywords: Building cladding; CFD simulation; Fire performance; Heat release rate; Significant parameters; Statistical analysis

ICSBE 2023-400

ACTIVE AND PASSIVE FIRE SAFETY SIMULATION FOR OFFICE BUILDINGS

R.A.D.M.Kahatapitiya[1*], W. J. B. S. Fernando [1], Priyan Mendis [2]

[1]Civil and Structural Engineering Consultants (Pvt.) Ltd., No. 189, Madinnagoda, Rajagiriya.

[2]University of Melbourne , Melbourne, Australia.

**Correspondence E-mail: dilan.cseci@gmail.com, TP: +94712081281*

Abstract: Building fire safety is becoming increasingly important in the present time. Therefore, re- quired level of fire safety should be ensured in buildings before their use. However, over design of fire protection leads to an additional cost. Preventing office fires is very important as because it is crucial to secure life safety as well as sensitive data and information in order to keep the office workflow running smoothly without any disruption. The present practice of providing fire safety is by taking into consideration the individual effect of active and passive fire protection. Hence, this will not accurately predict real fire safety of the building. Therefore, to overcome this issue, a combined effect of active and passive fire protection measures can be considered. Thus, a numerical modelling approach was selected and used to predict the fire safety achieved considering the combined effect of fire protection measures. The study was conducted for an office building and evacuation time was selected as the main output. The model results have shown increased fire safety due to the combined effect. Therefore, the results can be used to select optimum combination of active and passive fire protection that leads to economical design and minimum expected loss.

Keywords: Active Fire; Passive Fire; Simulation; Office buildings

AN INVESTIGATION OF THE APPLICABILITY OF THE BIOMIMICRY CONCEPT FOR DRR AND SOCIAL ENTERPRISES

ICSBE 2023-170

A NATURE-INSPIRED SOLUTION FOR ENHANCED IMPACT RESISTANCE OF STRUCTURES

H.M.T. Sajana[1], P.L.N. Fernando[1*]

[1]Department of Civil Engineering, Faculty of Engineering, University of Moaratuwa, Moratuwa, Sri Lanaka.

**Correspondence E-mail: lakshithaf@uom.lk, TP: +94777202638*

Abstract: High-velocity impact loads pose significant challenges due to their potential to generate dynamic responses in structures, which in turn can cause severe damage. This study investigates nature-inspired solutions to minimize damages resulting from high-velocity impact loads on structures. By analyzing the basic elements of several existing biological systems and their contribution towards the structural integrity of these systems, key potential characteristics that can be translated into impact-resisting structures have been identified. In this study, a solution that is inspired by the mantis shrimp arm has been developed; as such, a multi-layered structure was designed using metallic materials that use the mantis shrimp arm's concept of elastic modulus gradient variation. In addition, a periodic variation of elastic modulus in the multi-layered model was also considered. These we carried out using a theoretical and numerical analysis. Based on a theoretical analysis involving shock wave propagation, this system demonstrated the potential to reduce the magnitude of the stress waves during an impact-loading event. The numerical analysis of this system was carried out using the nonlinear finite element software Abaqus, where the impact of a metallic flyer at a known velocity on a target of the multi-layered structure was simulated. The magnitude of the incident stress wave of the final material in the target was obtained to evaluate the performance of this system. The results demonstrated that the proposed multi-layered system has the potential to reduce the magnitude of the incident stress waves in the system when compared to the monolithic system with no variation of the elastic modulus. Further comparisons of the graded and periodic variations of the elastic modulus have also been presented and discussed to highlight the applicability of the proposed system in real-world applications.

Keywords: Elastic modulus gradient; Impact resistance; Nature-inspired; Multi-layered structure; Stress waves.

ICSBE 2023-403

AN INVESTIGATION OF THE APPLICABILITY OF BIOMIMICRY CONCEPTS IN SOCIAL ENTERPRISES' (ES) RESILIENCE

G.R.S.D. Gamage[1*], K. Hemachandra [2], P.B.R. Dissanayake [3], D. Amaratunga[4], R. Haigh[4]

[1]Green Building Council of Sri Lanka, 120/10, Vidya Mandiraya, Vidya Mawatha, Colombo 07, Sri Lanka.

[2]Global Disaster Resilience Centre, Department of Management, Huddersfield Business School, University of Huddersfield, UK.

[3]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Sri Lanka.

[4]Global Disaster Resilience Centre, Department of Biological and Geographical Sciences, School of Applied Sciences, University of Huddersfield, UK.

**Correspondence E-mail: grsdgamage@gmail.com, TP: +94716496485*

Abstract: Social Enterprise (SE) is an emerging segment of the entrepreneurship field. It has been set up for the purposes of creating social, economic, and environmental value while fulfilling conventional business objectives. Therefore, by developing and utilizing local resources, social enterprises have the potential to develop sustainable and resilient community business models. Nevertheless, as with many other business models, SEs too face challenges. On the other hand, biomimicry concepts have been utilized in sectors such as innovation, production processes, resilience field and so on as an emergent discipline that explores the operations and lessons inspired by nature to solve human problems and challenges. It is the emulation or imitation of nature in its many forms, systems and processes to solve the most pressing challenges our world faces today. Therefore, this study aims to investigate the potential applicability of biomimicry concepts and practices in SEs addressing their challenges to achieve its objective, a desk review was conducted focusing on the capacity of biomimetics to enhance the resilience and growth of social enterprises. The findings reflect that, despite the exponential growth of biomimicry as a field and our understanding of its economic impact, what drives nature-inspired innovation remains elusive. Additionally, linking the challenges faced by social entrepreneurs to biomimicry can make the plans and businesses of social enterprises resilient. Consequently, biomimicry emerges as a pivotal instrument grounded in nature, facilitating innovation aligned with evolving values in the 21st century. Its capacity to foster the resilience of social enterprises holds promise for contributing to the advancement of a green economy.

Keywords: Biomimicry; Social Enterprises; Resilience; Challenge

ICSBE 2023-404

REVIEW OF NATURE INSPIRED SOLUTIONS FOR DISASTER RISK REDUCTION

Panchali Dias[1] . Nuwan Dias[2*] . P.B.R. Dissanayake[3]

[1] Huddersfield University, United Kingdom

[2] Springer Heidelberg, Tiergartenstr. 17, 69121 Heidelberg, Germany

[3]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Sri Lanka.

**Correspondence E-mail:* lncs@springer.com

Abstract: This research advocates for a transformative shift in the built environment towards disaster risk reduction (DRR) and promoting design, operational and systematic approaches in using Nature Inspired Solutions (NIS) in achieving DRR. The article primarily focuses on ecological and social systems with the shift from conventional sustainability and resilience strategies within practice. Exploration of novel technologies and biomimicry is required to accomplish this, exposing untapped potential in NIS for DRR. Despite expanding biomimicry research, this study underscores the lack of biomimicry research in DRR and indicates prospects for 'system-level' applications. The comprehensive literature review discloses gaps in the articulation of sustainability and resilience, advantages, recommending convergence with broader industry trends. The research submits as a comprehensive analysis as well as the foundation for constructing innovative solutions in the area of NIS for DRR. It facilitates a thorough understanding for scientists, policymakers, planners and other stakeholders in the area of NIS for DRR as a documented literature source. The aim of the paper is to promote a more structured and organized understanding on the current state of the art in NIS for DRR, whereby deriving objectives as such; identifying current approaches suggested by other researchers and the ones that are already implemented, discuss the current limitations associated with applying biomimicry for DRR and any suggestions of improvement, take a look at the future prospects in this study area and impart any ideas for future reference and mainly to emphasize on the importance of NIS in DRR in the current stage of globalization aiding the betterment of tomorrow.

Keywords: Nature Inspired Solutions (NIS); Disaster Risk reduction (DRR); Biomimicry; Green Infrastructure; Eco – system

CONSTRUCTION MANAGEMENT

ICSBE 2023-17

STRATEGIC ASSET MANAGEMENT FRAMEWORK FOR CENTRAL ENGINEERING CONSULTANCY BUREAU (CECB)

B. H. J. Bulathsinhala[1*], K. K. K. Sylva[2]

[1]Central Engineering Consultancy Bureau, Colombo, Sri Lanka

[2]University of Peradeniya, Peradeniya, Sri Lanka

**hjayanath@gmail.com, TP: +94711857146*

Abstract: Asset Management (AM) is increasingly considered a contributor to achieving competitive strategy for organisations. A strategic approach for tangible and intangible assets and human resources in organisations allows for better efficiency and quality output. Although public sector organisations know that assets are vital in fiscal responsibility and implementing organisational missions, resource management frameworks are either missing or not given thought. The non-profit-oriented nature and the complexity of goals are challenges for developing public sector AM frameworks. Central Engineering Consultancy Bureau (CECB), a public sector organisation in Sri Lanka, plays a significant role in the construction industry by contributing to the built environment. Both public and private infrastructure development with national and international affiliations and recognition are substantial activities of CECB. However, a practical AM framework was a gap identified for the organisation to contribute to the country's sustainable development of the built environment by providing the necessary service while paying attention to the adequacy of public sector resources. This study was performed to identify the practices of asset handling in CECB and verify the gaps in the current approach to develop a practical AM framework for the organisation. A qualitative study with 15 in-depth interviews and two focus group interviews was conducted for data collection. Thematic analysis was used to analyse data and identify current AM indicators, which were compared with preventing successful AM practices. The study disclosed that the missing role of an asset manager affects the function of the asset provider's operational task control activities, which disturbs an effective contribution to the built environment. Finally, an AM framework was developed for the organisation to provide the service necessary for a sustainable built environment. Further studies on asset management of Sri Lankan public sector organisations are recommended to utilise public assets effectively for sustainability.

Keywords: Resources; Asset Management; Sustainability; Built Environment

ICSBE 2023-74

IMPACTS OF URBAN SPRAWL ON WETLAND LAND COVER DYNAMICS: A SPATIAL AND TEMPORAL ANALYSIS FOR THE CASE OF COLOMBO

Christeen S.K.P[1], Jayasooriya V.M [1,2*]

[1]Department of Forestry and Environmental Science, Faculty of Applied Sciences, University of Sri Jayewardenepura, 10250, Sri Lanka

[2]Department of Geography, Geomatics and Environment, University of Toronto Mississauga, Canada

**Correspondence E-mail: varuni.jayasooriya@utoronto.ca*

Abstract: The rapid increase in urban population has led to urban sprawl in many developing countries, resulting in significant alterations to land use and land cover (LULC) patterns. This research investigates the effects of urban sprawl on wetland land cover dynamics in the Colombo district over a span of 40 years. By analyzing C2L2 Landsat images with RGB Band values of 7/8/9 and 10% cloud cover from 1997, 2007, and 2017, the study examines changes in LULC patterns. The built-up areas extracted from Interactive classified LULC images for the aforementioned years were utilized to identify spatial patterns of urban sprawl. The level of compactness in the Colombo district was measured using Shannon's entropy method, while Relative entropy was employed to scale the range from 0 to 1. The study covers all District Secretariat Divisions (DSDs) within the Colombo district. The findings reveal a significant reduction in wetland areas due to extensive expansion of built-up areas within the city. Urban sprawl exhibited a leapfrog pattern, expanding from the core area to small towns, primarily along residential roads. Notably, the DSDs of Colombo, Maharagama, Moratuwa, Padukka, Rathmalana, Seethawaka, and Thimbirigasyaya demonstrated decreasing entropy values, indicating consolidation of built-up patterns over time. Conversely, the DSDs of Dehiwela, Kaduwela, Kotte, and Sri Jayawardenapura exhibited stable entropy values, reflecting a consistent distribution pattern of built-up areas. The DSD of Homagama exhibited an increasing entropy value, suggesting a more dispersed built-up pattern. Overall, the study highlights a significant loss of wetlands over time, projecting their complete disappearance in Colombo DSD by 2060. These findings demonstrate substantial changes in LULC, converting wetland patches into non-natural uses. The study offers valuable guidance for mitigation in urban and environmental planning, aiding the development of effective policy initiatives to address the challenges posed by urban sprawl.

Keywords: Urban sprawl; C2L2 Landsat; RGB values; Wetland cover; Sustainable land use planning

ICSBE 2023-109

AWARENESS AND PERCEPTION OF QUANTITY SURVEYORS TOWARD THE SMART CONSTRUCTION CONCEPTS

R. S. V. Rajapaksha[1], K. Devapriya [1], M. L. S. S. Fernando [1*]

[1]University of Moratuwa, Sri Lanka

**Correspondence E-mail: shamalfernando96@gmail.com, TP: +94715659198*

Abstract: The construction industry is one of the largest industries in the world. However, it demonstrates a slower growth rate along with the adaptation of technology. The lack of agility in the construction industry to integrate modern technology has become a major concern for the poor involvement of technology. Hence, it is essential to upgrade the knowledge of the construction industry professionals with the development of the construction industry. The Quantity Surveyor is a key player in the construction industry who is responsible for the contract administration, cost management and maintenance of construction projects. Hence, it is required to upgrade the level of perception of Quantity Surveyors along with the evolution of the construction industry. The research aimed to determine the perception of Quantity Surveyors regarding new smart concepts and new technological trends relating to the construction industry. The research was conducted along with a mixed research approach combining both a questionnaire survey and semi-structured interviews among quantity surveyors. The potential quantity surveyors were selected using a cluster sampling method. Accordingly, 9 interviewees and 100 questionnaire survey respondents participated in the research. The quantitative and qualitative data were analysed using the Relative Important Index (RII) and manual content analysis respectively. A framework developed to improve the knowledge of the quantity surveyors in smart construction focusing on key technologies. Therefore, the organizational and individual level commitments and actions ensure the reduction of the gap between evolving professions and the evolving construction industry. The key strategies were CPD, University teaching and academic publications. These research findings expand the knowledge of modern construction technology and its involvement in the construction industry. Further recommends the importance of knowledge and awareness of modern construction technologies for improved performance.

Keywords: Big data; BIM; Blockchain; IoT; Machine Learning; Quantity surveying

ICSBE 2023-113

ECONOMIC AND ENVIRONMENTAL FEASIBILITY OF PRECAST CONCRETE WALLING SYSTEMS IN MULTI-STORY BUILDING CONSTRUCTION – A LIFE CYCLE PERSPECTIVE

B. Rathnayake[1*], C. Jayasinghe[2], P. Perera[3]

[1]RMIT University, Melbourne, VIC 3000, Australia

[2] Department of Civil Engineering, University of Moratuwa, 10400, Moratuwa, Sri Lanka

[3] Southern Alberta Institute of Technology (SAIT), Calgary, Canada

**Correspondence E-mail: bimali.rathnayake@rmit.edu.au, TP: +61421561145*

Abstract: Rapid urbanisation and growing metropolitan populations require efficient construction methods. Precast construction technology offers high-quality finishing, construction time reduction, low labour requirement, minimal waste, and an environmentally friendly solution compared to traditional monolithic construction methods. Despite these benefits, multistorey building construction in Sri Lanka is primarily based on traditional on-site construction practices. Therefore, this study focused on the economic and environmental feasibility of using precast concrete walling systems in multi-story building construction from a life cycle perspective. A precast concrete walling system was compared with a conventional cement sand block (CSB) walling system in terms of life cycle cost and life cycle assessment. The eco-efficiency index was used to evaluate the overall impact. The results indicate that the CSB walling system is more cost-effective than the precast concrete walling system in the long run, with a 7.8% difference in net present value. Although the CSB walling system is more cost-effective than the precast walling system, the precast walling system offers a higher eco-efficiency index with a 0.5% difference. In conclusion, the economic and environmental impacts of the two walling systems are in a similar range, while the precast walling system offers considerable time and labour savings with improved quality. Hence, the findings of this study help to select a walling material for multi-story building construction from a broader perspective.

Keywords: Precast Construction; Precast concrete walling systems; Life Cycle Cost (LCC); Life Cycle Assessment (LCA); Eco-Efficiency Index

ICSBE 2023-133

FLEXIBILITY TO INCORPORATE CIRCULAR ECONOMIC PRACTICES WITHIN BUILT ENVIRONMENT PROCUREMENT CONTRACTS IN SRI LANKA

R. R. M. M. K. Wadugodapitiya[1*], K. K. K. Sylva[1], S. M. Dissanayake[1]

[1]University of Peradeniya, Peradeniya, Sri Lanka

**Correspondence E-mail: manjulawadugodapitiya@yahoo.com, TP: +94772415357*

Abstract: Globally, the construction industry is heavily responsible for natural resources, energy consumption, and waste generation. These enormous developments have countless impacts on the environment, society and economy. Sustainable developments with a Circular Economy (CE) provide the best solutions to the issues mentioned above. CE transforms waste generated through the linear economy as input to the same or a new production cycle, which reduces waste generation and virgin resource consumption. CE adoption in Built Environment (BE) contracts is still in a primitive stage with a lack of knowledge and awareness of Circular Economic Practices (CEP). The study aims to identify the flexibility of BE contracts in Sri Lanka to utilize the CEP through a systematic review based on the 10R concept of CE. Flexibility is present in the application of CEP through Conditions of Contracts (COC), Specifications, and Environmental Management Plans (EMP). CEP within COC was recognized as *implicit*, while Specifications and EMP focus on CEP explicitly. Hence, these practices were identified as *partially explicit* and *explicit* practices. Eight of the CEP from the 10R concepts were revealed under the Specifications. Seven R concepts were discovered in the factor EMP. However, one R concept, Remanufacture, was not explicitly or implicitly present in the contractual documents. This study enhances the application possibilities of CEP in BE projects by revealing the opportunities for CE practices within contractual documents. Industry practitioners will benefit by identifying the potential of contractual documents such as COC, specifications and EMP for the application of CEP at the initial stages of projects. Further, the study will open up possibilities of identifying more CE practices that could contribute to the sustainable development of the BE. It is recommended to study the contractual documents further to include sustainable practices for the benefit of the environment, society and the economy.

Keywords: Circular Economic Practices; Flexibility; Sustainability; Built Environment

ICSBE 2023-151

STRATEGIES TO OVERCOME COMMUNICATION DEFICIENCIES IN MANAGEMENT CONTRACTS IN SRI LANKAN CONSTRUCTION INDUSTRY

M. Dinujanth[1], I.S. Gamage[2], B.C.T.M. Karunaratne[3*]

[1]Oracle Consultants (Pvt) Ltd., Moratuwa, Sri Lanka.

[2] School of Engineering, Design and Built Environment, Western Sydney University, Australia.

[3]Sri Lanka Institute of Information Technology, New Kandy Road, Malabe, Sri Lanka.

**Correspondence E-mail: karunarathne7tania@gmail.lk, TP: +94716773345*

Abstract: Construction is an ever-changing and fragmented industry with contractual interactions where a lack of mutual respect is prevalent. The standard of communication has a significant impact on construction projects, notably management contracting, a form of construction in which effective information management among stakeholders is a key driver for the construction project. There is a risk that management contract projects will fail due to communication deficiencies arising out of conflicts among parties, cost overruns and construction project delays, and many other challenges. As evidenced by the fact that the management contracts in Sri Lankan construction sector encounter numerous challenges due to communication deficiencies, the aim of this study is to investigate strategies to overcome the communication deficiencies in management contracts in Sri Lanka. A detailed review of the literature has been conducted to identify the communication deficiencies in management contracts and the importance of having proper communication in management contract projects. A qualitative research approach was adopted, and semi-structured interviews were conducted with thirteen local expert professionals from management contract procurement projects. The findings were analysed using NVivo-based content analysis. The findings revealed that some of the most significant communication deficiencies in management contract projects are transferring inaccurate information, inadequacy of information, lack of mutual respect, less use of technology, and lack of records. Recruiting experienced professionals, checking and improving information, discussion and clarification, adhering to proper protocols, working with deadlines, having good understanding and communication among the staff, and using correct and suitable software can be emphasised as the proposed strategies for mitigating identified communication deficiencies. By integrating all of the research findings, a framework was developed that will assist industry practitioners in the successful selection of an appropriate strategy to minimise a specific communication deficiency which avoids conflicts and contributes to the successful completion of construction projects.

Keywords: Construction; Communication Deficiencies; Management Contracts; Strategies

ICSBE 2023-157

EFFECT OF CURRENT ECONOMIC CRISIS ON CONSTRUCTION CONTRACTORS IN SRI LANKA: AN EXPLORATORY STUDY ON SMALL-SCALE CONTRACTORS

M. T. D. Perera[1], K. A. N. Gunarathna [2*], B.C.T.M. Karunaratne [3]

[1]Freelance Quantity Surveyor

[2]Lecturer, Sri Lanka Institute of Information technology, New Kandy Road, Malabe, Sri Lanka

[3]Freelance Quantity Surveyor

**Correspondence E-mail: nishanthi.g@sliit.lk, TP: +94766854980*

Abstract: Sri Lankan construction industry is a key driver of economic growth and has always been inevitably connected to the national economy. As Sri Lanka is currently experiencing tremendous economic instability, the construction industry has also been severely impacted. Sri Lankan economy has been victimized at great risk including high debt levels, weak fiscal base, foreign currency crisis, high inflation, and weak macroeconomic indicators. As evidenced by the fact that, small-scale contractors are mostly suffering as a result of the economic crisis, this study aims to identify strategies to control the financial issues faced by the small-scale construction contractors in the Western Province, Sri Lanka. A literature review has been conducted to study the current economic crisis in Sri Lanka and its impact on the local construction industry. Mixed method research was used in this study which includes both qualitative and quantitative approaches. Preliminary semi-structured interviews with construction industry experts were undertaken to develop a basic comprehension of the industry's existing status and 40 questionnaires were shared among professionals from C6 and below-graded construction companies in the Western Province of Sri Lanka according to the Construction Industry Development Authority (CIDA) grading scheme. Qualitative data collected were analyzed using thematic analysis and quantitative data were analyzed using descriptive statistical analysis using the weighted mean method. According to the study findings, small scale contractors are facing financial issues due to price escalations of construction materials and many difficulties such as delays in receiving payments, cash flow disruptions, supply chain management issues, taking over of projects by large companies, employee and labour shortages and restrictions on material imports. The majority of small-scale contractors have taken temporary strategies to overcome the challenges. Hence, the study proposes few strategies including the profit margin management until the breakeven level of the company, choosing small-scale projects over large-scale projects, using investment schemes with foreign clients which would assist small-scale contractors to overcome financial challenges amid the economic crisis in Sri Lanka.

Keywords: Economic crisis; small-scale contractors; Sri Lanka

ICSBE 2023-158

A BIM-BASED ROAD MAP TO IMPLEMENT LEAN CONSTRUCTION PRINCIPLES TO MINIMIZE WASTE IN CONSTRUCTION PROJECT

M.G.D.M.Y. Wickramasinghe[1], H. Bandara [1*], U.S. Perera [1*], R.M.K. Sandamal [1]

[1]Sri Lanka Institute of Information Technology, New Kandy Road, Malabe

**Correspondence E-mail: hemantha.b@sliit.lk, TP: +94 71 927 2431*

Abstract: Modern construction projects are complex due to its sophisticated architectural forms, hundreds of activities, and time-consuming operations, yet clients push contractors to finish projects within a limited time. Such complexity leads towards unmanaged projects that may lose about 57% of useful time in the absence of state-of-the-art techniques such as lean practices. The lean construction (LC) where lean practices are applied has a high potential to minimize construction waste and maximize profits. Building information modelling (BIM) has identified as a viable solution in making LC a reality in construction projects. However, LC has not penetrated Sri Lankan construction projects due to lack of awareness, limited research studies, infant-stage technology, and absence of guiding documents. To cater these issues, this study develops a road map to implement lean construction practices in construction-related organizations by utilizing a BIM-based approach. Moreover, this study identifies types of waste and waste sources by conducting a questionnaire survey among construction professionals in Sri Lanka. Afterward, each waste source is mapped to a solution based on LC practices which is further supported by BIM-based approach. The findings of the study reveal that excess materials, defects, and unnecessary material movements as the top wastes in a construction project while improper storage and handling as key sources of waste. Based on the findings, the authors finally suggest a four-stage LC road map which can be adopted by construction stakeholders to minimize waste by maximizing profits.

Keywords: Lean Construction; Building Information Modelling; Construction waste; Total quality management; JinTime Time

ICSBE 2023-168

NEW WORK STRATERGIES TO OVERCOME THE IMPACT OF UNFORSEEN DISRUPTIVE EVENTS FOR CONSTRUCTION CONSULTANTS

S Hettiarachchi[1], C Allis [2], Y.K Delpachitra [3*]

[1]Oxford Brookes University, United Kingdom.

[2] Sri Lanka Institute of Information Technology, Malabe, Sri Lanka

[3] Skills College of Technology, Nugegoda, Sri Lanka

**Correspondence E-mail: ykdelpachitra@gmail.com, TP: +94 766206717*

Abstract: Unforeseen disruptive events pose significant challenges to the construction industry, impacting project timelines, budgets, and overall success. In order to mitigate these disruptions, construction consultants play a critical role. Hence, it is essential to identify alternative methods to overcome the consequent downfalls with the new normal approaches. The uniqueness of the research was emphasized as to identify new work strategies that construction consultants can employ to overcome the impacts of unforeseen disruptive events. The research aim was achieved with three main objectives by using literature review and the data collection. The data collection was done through questionary survey with 30 industry professionals and semi-structured interviews with randomly selected 5 professionals who work in the construction industry. Under that first objective, it was identified the possible unpredictable disruptive events that could take place, which could affect the construction project sequence like pandemic situations, adverse weather conditions, and terrorist attacks. Secondly investigated the various problems faced by the consultant party of the construction industry like time overrun, cost overrun, dispute, suspension of investment, delays and economic and financial recessions with the work strategies prevailed so far, due to the lack of new work strategies to face unforeseeable disruptive events. The third objective was to identify the new work strategies that could be manipulated to replace the prevailing system like application of modern technology, and software usage, value engineering, risk management and planning and progress monitoring system. Construction consultants can navigate through disruptive events more effectively, minimize their impacts, and ensure successful project delivery by adopting these new strategies. Hence this research contributes to the construction industry by providing practical recommendations to improve and advance the capability of construction consultants in handling unforeseen disruptive events. The findings inform decision-making processes, improve project planning and execution, and contribute to more resilient and successful construction projects.

Key words: Construction Industry; Consultant party; Unforeseen Disruptive Events; Problems; New Work Strategies

ICSBE 2023-225

A STUDY ON THE MISSED OPPORTUNITIES THROUGH THE SRI LANKAN CONSTRUCTION INDUSTRY TOWARDS A SUSTAINABLE ECONOMIC GROWTH

WDBJ Jeewananda[1*], SD Jayasooriya[2]

[1] Department of Quantity Surveying, General Sir John Kotelawala Defence University (Southern Campus), Sri Lanka.

[2] Department of Industrial Quality Management, General Sir John Kotelawala Defence University (Southern Campus), Sri Lanka.

**Correspondence E-mail: bimsaraj@kdu.ac.lk, TP: +9471 053 6395*

Abstract: Being known as a developing country, Sri Lanka has been struggling to attain a sustainable economic growth since decades. Primarily with the civil war that continued for over 30 years, later the terrorist attacks in 2019, followed by the COVID-19 outbreak in early 2020, Sri Lanka's economy was facing a massive downfall. Construction industry, which is known to be the 4th highest contributed sector in the country, is recognized by past studies about its connection to the national economy. Yet, exposing a significant gap in the available literature, there aren't satisfactory studies done on identifying the available opportunities within and through the Construction industry towards the country's economic growth, which is aimed to be fulfilled by this study. A mixed approach using both qualitative and quantitative data, gathered respectively through past literature, interviews and questionnaire surveys with industry experts and professionals were used to achieve this study's objectives. The qualitative data obtained through expert interviews were analysed using content analysis, whereas they concluded to having new opportunities by the means of; new Construction technologies, job generation through Constructions, material manufacturing, tourism industry and availability of world-recognized Construction education; which could be used towards a sustainable economic growth in the country. Furthermore, strategies were suggested individually on each identified opportunity on how to practically implement them in the country. To achieve the aim of the study, suggested strategies were ranked according to the views of industry professionals to identify the most effective ones as; using new Construction technologies for lifetime energy efficiency, providing opportunities for local contractors to partner with foreign contractors, using traditional Sri Lankan Construction methods and designs for tourist attractions, innovating new Construction materials using local raw materials and by-products, and developing Construction education institutions that could intake foreign students to the country.

Keywords: Construction industry; Sri Lanka; Sustainable economic growth; Missed opportunities; Strategies

ICSBE 2023-227

WHAT DEMOTIVATES HOMEOWNERS TO RETROFIT THEIR HOUSES: A SYSTEMATIC REVIEW

C, Panakaduwa[1*], S,P, Coates[1], M, Munir [1]

[1]*University of Salford, United Kingdom.*

**Correspondence E-mail: c.s.panakaduwagamage@edu.salford.ac.uk*

Abstract: The study identifies the factors that demotivate homeowners from retrofitting their houses. Retrofit is defined as improving the energy performance, ventilation or reducing carbon emission of a building. According to the statistics, the progress rate of sustainable housing retrofit in the United Kingdom is poor, which has become a critical bottleneck in mitigating climate risks under the UK climate actions. The housing sector is responsible for around 18% of the total UK Carbon emissions. One of the main barriers driving housing retrofit is poor homeowner motivation for retrofit. A systematic literature review approach has been used in this study. The PRISMA method of systematic review was adaptively followed to make the review more transparent, accurate and standard. The findings include personal and social drivers, financial constraints, reliability/trust and government policies as the main factors of demotivation. The total list consists of 67 demotivating factors from 40 high-rank journal articles. The findings are important for policy actions as well as for driving retrofit programmes in the construction industry. The homeowner's decision-making is a deterministic factor in driving sustainable retrofit. Thus, identifying motivational barriers will be a key priority in driving retrofit at a scale.

Keywords: Climate action; Decision-making; Energy retrofit; Homeowners; Motivation

ICSBE 2023-244

CONSTRUCTION CONTRACTUAL ISSUES AND PROSPECTS APPLYING OF ALTERNATIVE DISPUTE RESOLUTIONS IN SRI LANKA

HN Hikkaduwa[1*]

[1]*Construction Industry Development Authority(CIDA),"Sawsiripaya"123, Wijerama Mawatha, Colombo 07*

**Correspondence E-mail: himal.n.hikkaduwa@gmail.com, TP: +94714870861*

Abstract: The construction sector, which accounts for roughly 6–7% of Sri Lanka's GDP, is a major contribution to the country's economic growth. Owing to the ester attack, global pandemic situation and subsequently, the economic & political crisis. was raised the costs & availability of materials & labour, suspensions & terminations of projects, and project cost & time overrun, and the industry suffered significantly. Those circumstances were cause & escalate disputes in the construction sector, such disagreements are negatively impact on the projects. Unless it effectively managed, those disputes often find their way to the formal justice system, and increasing the case burden of the court system of the country. Compared to other countries in the region, has a substantially higher per capita cost of construction. This will have a detrimental effect on potential investors. The Alternative Dispute Resolutions (ADR) mechanisms is the different ways people can resolve disputes without a trial. Common ADR processes include mediation, conciliation, adjudication, arbitration, and neutral evaluation. These processes are generally confidential, less formal, and less stressful than traditional court proceedings. ADR often saves money & speeds settlement. In ADR mechanisms, parties play an important role in resolving their own disputes. This often results in creative solutions, longer-lasting outcomes, greater satisfaction, and improved relationships among contracting parties. Presence and recognition of ADR in country will reduce the cost & time overrun in projects and attracts the investors as well. Therefore, it is extremely important that stakeholders are well aware on ADR mechanisms, that enables them to resolve disputes out of court, without burden to the court system. Accordingly, this paper is focused on current practice of ADR and possible alternations to promote the in the Sri Lankan construction industry, focusing reducing the time & cost overrun of the project.

Keywords: Alternative Dispute Resolutions (ADR) mechanisms; Time & cost overrun; Saves money & speeds settlement

ICSBE 2023-276

ASSESSING THE READINESS FOR DIGITAL TECHNOLOGIES ADOPTION FOR ENHANCING PRODUCTIVITY IN THE SRI LANKAN CONSTRUCTION INDUSTRY

I.H.N. Chathuranga[1], C.S.A. Siriwardana [2*], I.E. Ariyaratne [1]

[1] Department of Civil Engineering, University of Moratuwa, Sri Lanka.

[2] School of Built Environment, Massey University, New Zealand.

**Correspondence E-mail: c.siriwardana@massey.ac.nz, TP: +64225727755*

Abstract: The Construction Industry (CI) is a vital industry that serves the nations worldwide through various infrastructure developments. As a result, the productivity of the CI has a direct impact on the country's economy. In the past, multiple researchers and organizations have made many efforts to improve the productivity of the CI. Despite this, the CI is contending with reduced productivity levels. The latest CI trend is improving productivity by digitalizing construction operations. Digital Technologies (DT) can potentially improve the productivity of CI, and many countries worldwide are moving towards construction digitalization. However, the efforts to adopt emerging DT within CI in Sri Lanka remain unsatisfactory. This scenario is even worsened by not having an idea about the readiness of the Sri Lankan (SL) construction organizations to adopt these digital technologies. Much existing research has focused only on individual DT adoption readiness and has only explored a limited range of DT types. Single DT adoption readiness assessments have not provided significant value to construction practitioners from a holistic perspective, particularly in the SL context. This research aims to comprehensively assess the SL construction organization's readiness towards DT adoption with a comprehensive literature review identifying 15 potential readiness indicators under the Environment, Technical, Organization, Leadership, and Workforce dimensions. These identified readiness indicators were then surveyed among the SL construction practitioners for data collection about the organizational readiness toward DT adoption. The outcomes of this research provide a comprehensive organizational readiness model and a simplified assessment tool for assessing the readiness of SL construction organizations toward DT adoption from a holistic perspective. It enables organizations to implement strategic plans to address existing issues and adopt these DTs into their construction processes to improve CI productivity.

Keywords: Digital Technologies; Construction Industry Readiness; Readiness Assessment; Digital Construction; Construction Productivity

ICSBE 2023-277

DEVELOPMENT OF A CRACK SEVERITY-BASED DAMAGE ASSESSMENT MATRIX FOR MASONRY BUILDINGS

Wickramathilake G G T D [1*], Jayasinghe C [1], Ariyaratne I E [1]

[1]Department of Civil Engineering, University of Moratuwa

**Correspondence E-mail: thariniwickramathilake97@gmail.com, TP: +94775291742*

Abstract: Deterioration resulting from cracks can undermine both the structural integrity and functionality of masonry buildings. Cracks can occur due to various factors such as poor workmanship, excessive loading, thermal movement, corrosion of reinforcement, faulty design, soil and foundation-related issues, and poor maintenance. The presence of cracks can increase the stress levels of the structure, potentially leading to the collapse of specific components or even the entire building structure. Therefore, it is necessary to conduct a crack severity-based damage assessment to ensure the safety of occupants, preserve property value, and maintain the integrity of our built environment. In response to the aforementioned need, this research aimed to develop a damage assessment matrix to determine the risk level of masonry buildings by considering the severity of cracks. Data was collected from 69 damaged masonry houses in Higurkgoda, Sri Lanka, and the key parameters to indicate the crack severity were identified. The weightages of these key parameters on crack severity were evaluated using the collected data within the context of the Analytical Hierarchy Process. Following that, the damage assessment matrix was developed based on these identified key parameters. In this study, crack width and nature of the crack (i.e., whether the crack is structural or non-structural) were identified as the key parameters for indicating crack severity. The developed matrix gives a value that represents the severity level of a crack based on the width and nature of the crack. This matrix facilitates the determination of the risk level of a masonry building by determining the severity of all cracks when armed with the width and nature of all cracks in the building. Given that the damages observed in the houses within the Higurakgoda division stem from the expansive nature of the underlying soil, the damage assessment matrix developed in this study finds practical application specifically for evaluating damages in masonry buildings resulting from the expansiveness of the underlying soil. By providing a means to quantify the extent of damage, predict potential risks, and facilitate timely corrective actions, this matrix proves instrumental in safeguarding against catastrophic disasters and minimizing structural damage in masonry buildings.

Keywords: Damage Assessment Matrix; Crack Severity; Masonry Buildings; Expansiveness of soil; Risk Level of buildings; Structural Safety

ICSBE 2023-342

THE INTEGRATION OF CIRCULAR ECONOMY PRINCIPLES WITH BIM-ENABLED MATERIAL PASSPORTS FOR SUSTAINABLE CONSTRUCTION

J.M.P.M. Jayawardane[1], I.H.N. Chathuranga [2], C.S.A. Siriwardana [3*], Wajiha Shahzad[3]

[1]Department of Civil Engineering, University of Moratuwa, Sri Lanka.
[2]Department of Architecture, University of Moratuwa, Sri Lanka.
[3]School of Built Environment, Massey University, New Zealand.
**Correspondence E-mail: c.siriwardana@massey.ac.nz, TP: +64225727755*

Abstract: The Construction Industry(CI) is a major contributor to environmental and climate change issues due to high raw material consumption, together with amplified generation of construction and demolition waste(CDW). Globally, 30%-50% of raw material usage and 15-21% of waste generation is due to the CI, which includes 3 billion tons of global CDW, annually. From this, only 30% is recycled and reused, and 70% is dumped into the environment, leading to critical environmental concerns. That highlights the essentiality of material circularity within the CI to tackle these problems. Circular Economy (CE), empowered by the recovering, recycling, and reusing construction materials, aims to keep products, materials, and resources in use for as long as possible and extract maximum value from them during their lifecycle. Effective material circularity is possible by identifying the material's life cycle, including the composition of the material, embodied energy, global warming potential, CO_2 emission, recycling potential, and other details. The Material Passport(MP) is a concept developed to trace the material life cycle with the above-mentioned details. In the past few years, the digitalized MP concept has boomed with advancements in the Building Information Modelling(BIM) platform, creating enormous advantages for sustainability in CI. With these BIM-enabled MP, the life cycle of the CI can be digitally traced, and the changes in the material can be effectively documented in real-time. However, in the Sri Lankan(SL) context, identifying these circularity methods is unsatisfactory. By systematically reviewing the literature published between 2013-2023, this study comprehensively presented the adaptability and advantages possible by employing BIM-enabled MP to the CI to fill the research gap available. These outcomes will be promisingly helpful to the Sri Lankan CI to achieve a sustainable CI by taking initiatives to the CE by enabling digitalized MP to the Sri Lankan construction industry (SLCI).

Keywords: Circular Economy; Material Passport; Life-Cycle Assessment; BIM; Sustainable Construction

ICSBE 2023-347

UNLEASHING POTENTIAL WITH GLASS WASTE IN MASONRY

O.M. Hasaranga[1*], C. Jayasinghe[1], K.P.I.E. Ariyaratne[1]

[1]Department of Civil Engineering, University of Moratuwa

** E-mail: Madurahasaranga50@gmail.com, TP: +94723094583*

Abstract: This research investigates the potential of incorporating glass waste as an environmentally friendly alternative in the production of concrete masonry blocks. Through innovative mix designs and meticulous batching techniques, the study aims to enhance both sustainability and material performance. The primary focus is on assessing the impact of varied percentages of glass waste on the compressive strength of concrete blocks, particularly when substituting manufactured sand and quarry dust. Additionally, adjustments in moisture content during batching were meticulously considered for precision. The experimental outcomes strongly support the feasibility of using glass waste as a substitute aggregate, revealing notable improvements in compressive strength. Furthermore, the research demonstrates the potential to reduce cement content without compromising structural integrity. This study underscores the significance of sustainable construction practices, emphasizing resource optimization and environmental preservation through the integration of glass waste. By showcasing enhanced block performance and the possibility of reducing reliance on traditional aggregates, this research presents a promising avenue for sustainable construction materials, aligning with the urgent need for eco-conscious solutions in the industry.

Keywords: Glass waste; Concrete masonry blocks; Sustainable construction; Aggregate replacement

ICSBE 2023-348

BEST PRACTICES OF OFF-SITE MANUFACTURING: LESSONS FROM AUSTRALIAN PREFAB MANUFACTURERS

J. Jayawardana [1, 2*], J. A. S. C. Jayasinghe [1], A. K. Kulatunga [1], M. Sandanayake [3], G. Zhang [2]

[1]Faculty of Engineering, University of Peradeniya, Peradeniya, 20400, Sri Lanka

[2]School of Engineering, RMIT University, Melbourne, VIC 3001, Australia

[3]College of Engineering and Science, Victoria University, Melbourne, VIC 3011, Australia

**Correspondence E-mail: janappriyalj@eng.pdn.ac.lk*

Abstract: Prefabricated construction is a modern method of construction that has increased benefits over the traditional way of construction. Off-site manufacturing is a crucial life cycle stage of the prefabricated construction process, where building elements are produced in an off-site factory. A controlled manufacturing environment enables competitive advantages such as improved quality control and monitoring and more opportunities for accompanying digital technologies. Identifying and understanding the best practices adopted by off-site manufacturers are imperative to further optimise and promote prefabrication in construction projects. Hence, the current study aims to conduct a qualitative content analysis to identify the best manufacturing practices of Australian off-site manufacturers. The analysis employed business information from fifteen Australian-based prefab manufacturers in NVivo to identify relevant best practices. The results revealed 12 best practice groups (themes) and 50 best practices. Technology and innovation and customer focus and customisation were the most significant themes identified through content analysis. Moreover, in-house research and development, digital software tool integration and continuous development and improvement of products were the most important best practices implemented by Australian prefab manufacturers. The current research outcomes can be referred to by keen prefab manufacturers in other regions to formulate further best practices and improve the already implemented ones.

Keywords: Best practices; Off-site manufacturing; Prefabricated construction; Qualitative content analysis; Prefab manufacturers

SUSTAINABLE TRANSPORT

ICSBE 2023-270

DEVELOPMENT OF A TRANSPORTATION SUSTAINABILITY RATING SYSTEM FOR ROAD CONSTRUCTION PROJECTS IN SRI LANKA

C.N.J Samaranayake[1*], G.N Samarasekara[1], K.M.C Konthesingha[1], W.M.N.R Weerakoon[1], R.S.M Samarasekara[1], R. Dissanayake[2]

[1]Department of Civil Engineering, University of Sri Jayewardenepura, 41 Lumbini Ave, Dehiwala-Mount Lavinia, Sri Lanka.

[2]Department of Civil Engineering, University of Peradeniya, Peradeniya, 20400, Sri Lanka.

**Correspondence E-mail: nayanathara96sam@gmail.com, TP: +94775998094*

Abstract: To encourage sustainable development in transport infrastructure, several Transportation Sustainability Rating Systems (TSRS) have been developed by different organizations around the world. However, Sri Lanka lacks a rating system in place for this purpose. Thus, this study aims to develop a TSRS to evaluate the sustainable performance of road construction projects in Sri Lanka. Initially, globally recognized existing TSRSs such as the Civil Engineering Environmental Quality Assessment and Awards Scheme (CEEQUAL), Envision and Greenroads were critically analysed together with GreenSL for transport infrastructure to identify their advantages and adoption. According to the outcomes, Greenroads was found to be more like the GreenSL for transport infrastructure rating system which is under development by the Green Building Council of Sri Lanka. Therefore, Greenroads and GreenSL were used to evaluate a case study project with the aim of evaluating the effectiveness of the GreenSL for the transport infrastructure rating system. Further, a questionnaire and several discussions were conducted with industry experts to obtain improvement suggestions for the GreenSL for transport infrastructure rating system as well as the relative weights therein. The results of the case study show that the GreenSL for transport infrastructure rating system is effective in terms of Relevance, Measurability and Uniqueness but less effective in terms of Reliability. The GreenSL for transport infrastructure rating system was developed as a 100-point scoring system including suitable sustainability indicators and weightings. Future studies can further improve this proposed rating system by incorporating emerging sustainability of best practices in its rating structure.

Keywords: Sustainability; Sustainable development; Transport infrastructure; Rating systems; Sri Lanka

ICSBE 2023-285

A PRICING POLICY FOR VEHICLES AND FUEL FOR SRI LANKA

L.S.M. Silva[1*], A.S. Kumarage [1], M. Mavin De Silva[1,2]

[1] Department of Transport and Logistics, University Moratuwa, Moratuwa, Sri Lanka.

[2] Department of Science of Technology Innovation, Nagaoka University of Technology, Japan

**Correspondence E-mail: sandaru.malinda8899@gmail.com, TP: +94779290875*

Abstract: Sri Lanka is facing an economic crisis, alongside congestion and emissions problems in its central commercial city hubs. The lack of a properly connected public transportation system has exacerbated these issues. Fuel pricing and vehicle pricing are critical policy factors in addressing transportation challenges. However, the effectiveness of current transport sector pricing in solving these problems remains uncertain. In recent years, the Sri Lankan government implemented measures such as a fuel pricing formula and tax concessions for electric and hybrid vehicles. However, the observed demand patterns for petroleum fuel do not indicate that the desired objective has been achieved, revealing inefficiencies in ad-hoc government decisions. This research examines existing fuel and vehicle pricing policies in Sri Lanka, comparing them globally while proposing more rational and development-based pricing policy recommendations. The specific research objectives include a global policy review and designing a pricing policy tool. The significance of this research lies in its usefulness in addressing the urgency of improving public transportation, addressing congestion pollution, and reversing the economic downturn in Sri Lanka. Global pricing strategies for fuel and vehicles reveal valuable insight for a scientific approach to fuel and vehicle pricing through outcome-based taxation, including promoting environmentally responsible practices and reducing dependence on imported goods.

Keywords: Fuel pricing; Vehicle pricing; Transportation; Policy analysis; Policy tool

ICSBE 2023-288

COMPARATIVE ANALYSIS OF THE EFFECT OF CIRCULAR AND HORSESHOE UNDERGROUND TUNNEL SHAPES ON THE REQUIRED SUPPORT PRESSURE IN THE GENERAL GEOLOGICAL CONTEXT OF KANDY CITY

M.A.K.V Warnakulasooriya[1*], B. Fernando[2]

[1,2]Department of civil Engineering and Build Environment,
Liverpool John Moores Univercity, UK.
**Correspondence E-mail: Kalpavirajww@gmail.com, TP: +94757674599*

Abstract: Rapidly expanding cities like Kandy in Sri Lanka frequently encounter obstacles linked to traffic congestion, sustainability concerns, and constraints on infrastructure expansion when it comes to urban development. Subway systems can be proposed as a sustainable remedy to tackle these issues. This research employs a multidisciplinary approach, encompassing geotechnical engineering, environmental science, urban planning, and transportation engineering methods to explore the correlation between the required support pressure to maintain the structural integrity of the tunnel shapes of circular and horseshoe in the general geological context of Kandy city with PLAXIS-3D. At this point, Tunnel Boring Machine (TBM) and New Austrian Tunnelling Method (NATM) are used to investigate these circular and horseshoe shaped tunnel designs respectively. In the field of underground construction, PLAXIS-3D software can be called as a successful tool for its ability to simulate complex soil-structure interactions. The data collected geologically for this purpose includes; information on soil types, groundwater levels, soil properties and other relevant material and equipment parameters. Then using finite element analysis software PLAXIS-3D, the detailed 3D models of the common geological strata of Kandy city were constructed to facilitate the tunnel geometry, stress and deformation analysis, visual representation, and to run the tunnel performance analysis. Based on stress distribution and deformation pattern analysis of these 3D models, it was possible to evaluate how tunnel shapes affect the surrounding soil and subsurface environment. Circular and horseshoe-shaped tunnels exhibit distinct support pressure patterns and stress distributions, affecting structural responses and displacement values in Plaxis-3D analysis under fed Kandy geological context. Finally, these findings contribute to optimizing the design and construction of appropriate tunnel shapes by exploring the correlation between the required support pressure based on tunnel shapes as an effective solution to promote sustainable development of Kandy city, improving safety and cost-effectiveness of underground infrastructure projects.

Keywords: Circular tunnels; Horseshoe tunnels; Finite element analysis; PLAXIS-3D

ICSBE 2023-289

SRI LANKAN VEHICULAR EMISSION ANALYSIS USING BIG DATA

Avishka Lakshan[1*], Amal S. Kumarage[1], M. Mavin De Silva [1, 2]

[1]Department of Transport Management & Logistics Engineering, University of Moratuwa, Sri Lanka

[2]Extreme Energy-Density Research Institute, Nagaoka University of Technology, Japan

**Correspondence E-mail: avishkalakshanwp@gmail.com, TP: +94772133028*

Abstract: Vehicular emissions pose a significant threat to environmental sustainability and public health in Sri Lanka, with the increasing number of vehicles on the roads exacerbating the problem. However, the lack of effective tools for measuring and managing emissions hinders effective policymaking in this area. This study aims to address this crucial issue by employing big data analytics to analyse vehicular emissions in Sri Lanka comprehensively. The study utilized a Vehicle Emission Test (VET) dataset spanning 2009 to 2020, comprising approximately 51 million data points. The data was thoroughly cleaned and pre-processed using Excel and R to ensure accuracy and reliability. To calculate CO_2 emission mass from vehicle exhaust gas, the equation proposed by Karunathilaka in 2018 was employed. The results revealed a consistent decrease in CO_2 emission mass per Liter of fuel consumed over time, indicating a positive shift towards more environmentally friendly vehicles. Diesel vehicles were found to emit lower CO_2 compared to petrol vehicles, aligning with global initiatives to mitigate greenhouse gas emissions. Additionally, the analysis highlighted the presence of intricate factors influencing CO_2 emissions beyond traditional metrics like mileage and vehicle age, emphasizing the need for further research. These findings have significant implications for theory, practice, and policy. They emphasize the importance of mitigating CO_2 emissions in the transportation sector and underscore the need for effective vehicular emission management, particularly in developing countries. The utilization of big data and advanced analytical tools can provide valuable insights into vehicular emissions and assist policymakers in making informed decisions to reduce the environmental impact of transportation. Overall, this research contributes to the pursuit of sustainable and greener practices within the transportation industry, facilitating a more sustainable and environmentally conscious future.

Keywords: Emission; CO_2; Air quality; Big Data; R Language; Regression

ICSBE 2023-324

USE OF GEOSYNTHETICS FOR SUSTAINABLE, ECONOMICAL, AND DURABLE ROAD PAVEMENT STRUCTURES

C. Gallage[1*], K. Wimalasena [2], A. Pathirana [1]

[1]Queensland University of Technology (QUT), Brisbane, Australia.

[2]Aurecon Group Pty. Ltdy, Brisbane, Australia.

**Correspondence E-mail: chaminda.gallage@qut.edu.au, TP: +61 7 3138 1034*

Abstract: Traditional road pavement construction methods rely heavily on quarried gravel. Thicker layers of granular material are often required when dealing with weak or soft ground conditions to mitigate the stresses exerted on the underlying soft subgrades. The depletion of natural resources, environmental issues associated with quarrying processes, and the global shift towards achieving net-zero emissions compel researchers and practitioners to investigate innovative materials and technologies that can enable the construction of sustainable, resilient, cost-effective, and environmentally friendly road pavements while reducing reliance on quarried gravel. In pursuit of this objective, this study focuses on the utilisation of geosynthetics to stabilise soft subgrades, thereby diminishing the need for substantial granular cover thickness. and enhancing the overall performance of the pavement structure. To achieve this aim, a series of model pavements were constructed within a 1m x 1m x 1.2m steel box (referred to as the model box). Various parameters, including subgrade stiffness, capping layer thickness, and geosynthetic types, were systematically altered during the construction of these models. Subsequently, the static plate load tests were conducted in a controlled laboratory environment. The test results provided valuable insights into the overall modulus/stiffness of the improved subgrade. The enhanced subgrade modulus, in turn, was integrated into the Australian granular pavement design chart to illustrate the advantages of geosynthetic embedment in soft subgrade stabilisation. The findings from this study suggest that the incorporation of geosynthetics can reduce the overall granular cover thickness by approximately 20%.

Keywords: Geosynthetics; Granular Pavements; Model Testing; Pavement Design

ICSBE 2023-406

CELLULAR AUTOMATA MODELING APPROACH TO FORECAST LAND USE CHANGES IN KATUNAYAKE AIRPORT CITY

K.D. Herath*, P.C.P. De Silva , P.K.S. Mahanama

MPhil Student, Department of Town & Country Planning, University of Moratuwa, Sri Lanka.

**Correspondence E-mail: kanakadh@gmail.com, TP: +94773208869*

Abstract: It is heavily expressed by the scholars in urban planning and its allied disciplines that an airport is an economic infrastructure, which effects to grow a city massively or to create new mega cities. Systematic strategic management of airport cities and the cognizant of the opportunities and threats become a prerequisite to reaping the full benefits for airport cities and the greater metropolitan they serve (Appold & Kasarda, 2010). An accurate land use foresting is the fundamental need for urban and regional planning, as it helps authorities to make informed decisions about infrastructure development, transportation planning, environmental conservation, and overall land management. Land-use models, especially cellular automata (CA)-based land- use models, offer a good platform to study urban dynamics (Al-Ahmadi, See, Heppenstall, & Hogg, 2009). The cellular automata concept is a popular modelling concept, which predict the future land uses, as it correctly detects the spatial location of change. A 5 km radius buffer area from the middle of the Katunayake Airport was selected as the study area. Then, land use maps were prepared in last five years for the study area. The study area was divided into 50m * 50m cells. The status of each cell in each year was identified according to the land use category, which were identified through the literature review. From 2019 to 2023, the land use change in each year in each cell was detected with neighbouring 8 cells. With those data, regression models for land use changes incorporating impacts from neighbouring cells were developed. Those regression models were applied to forecast the land use change in each cell in each year from 2023 to 2028. Based on those predictions, land use maps were prepared for 2024, 2025, 2026, 2027 and 2028. Relevant authorities can use these maps to take many decisions related to the land use management to maximize the benefits from an airport city.

Keywords: Airport City, Cellular Automata, Land Use Forecasting and Modelling

ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE DEVELOPMENT: CHALLENGES AND OPPORTUNITIES

ICSBE 2023-205

DEVELOPING A MATHEMATICAL MODEL AND MOBILE APP FOR GREENHOUSE MONITORING AND CONTROL USING SENSOR INTEGRATION

M.T.U.D.Mallikarathne[1*], A.M.H.M.Abeysinghe [1], A.P. Wijayawantha [1]

[1]Department of Instrumentation and Automation Technology, Faculty of Technology, University of Colombo

**Correspondence E-mail: 2017t00042@stu.cmb.ac.lk, TP: +94742413659*

Abstract: The exact regulation and monitoring of environmental factors like air quality, soil moisture, and light intensity are necessary for achieving optimal plant growth. These requirements are frequently not met by conventional agricultural techniques which results in yields that are less than ideal. Contrarily, greenhouse farming provides a solution by building managed habitats specifically designed for particular crops. However, even farming in a greenhouse presents difficulties because ongoing manual inspection takes time and is prone to mistakes. By integrating sensor integration, mathematical modeling, and a mobile application for greenhouse monitoring and control, this study offers an all-encompassing solution. To solve these issues, a prototype system is created. Real-time data on essential parameters are gathered by seamlessly integrating multiple sensors throughout the greenhouse. The system's intuitive smartphone application is its brains. Farmers now have immediate access to environmental data and trends for the greenhouse thanks to this app. Adaptive weighted sensor data fusion is an innovative idea in contemporary agriculture. This method maximizes the accuracy of data integration by dynamically updating the relevance of sensor inputs based on altering environmental conditions. By combining the most pertinent data from multiple sensors, including temperature, humidity, and light intensity, a thorough and up-to-the-minute picture of the agricultural environment is created. This adaptive weighted sensor data fusion technology, when combined with mathematical models, provides farmers with precise insights and real-time modifications, encouraging improved yields, resource efficiency, and sustainable farming practices. A revolutionary method of greenhouse farming is provided by the combination of sensors, mathematical modeling, and a mobile application. Precision monitoring and control are made possible by this cutting-edge system, which ultimately improves crop growth and yield. This study advances the development of sustainable and effective farming techniques by utilizing technology to harmonize agricultural operations.

Keywords: Sensor integration; Greenhouse monitoring and controlling; Mathematical Model; Regression; Mobile application

ICSBE 2023-260

ENHANCING THE FLOOD MODELING ACCURACY UNDER VARYING SPATIAL SCALE FINER RESOLUTION WEATHER DATA

Susantha Wanniarachchi[1,2*], Ranjan Sarukkalige[2]

[1] SLIIT, New Kandy road, Malabe, Sri Lanka,

[2] Curtin University, Kent St, Bentley WA 6102.

**Correspondence E-mail: susantha.wanniarachchi@curtin.edu.au, TP: +61499167266*

Abstract: Global Climate change is leading to extreme weather conditions, and they occur more frequently. Floods are among the major natural disasters that cause loss of lives and economic damage worldwide. Therefore, reliable flood forecasting and warning systems are required to alert the public and governing authorities as early as possible. In most countries, river basins are sparsely gauged, and lack of accurate and adequate rainfall, soil moisture, and discharge measurements. This contributes to higher uncertainty in predicting hydrological responses in such areas. Considering the recent severe floods and water management issues of the City of Wangaratta in Australia, the Ovens River basin (>6000 km2) in Australia has been modelled using GR4H – hydrologic model with lag and route channel routing. A moderate density of weather stations with hourly discharge, precipitation, and PET data (2007-2017) were used in a semi-distributed catchment model with 53 sub-areas. Data sparse situation was simulated with only five weather stations for the entire basin. Model results revealed 0.77 NSE for calibration for a 7-year period, and 0.81 NSE for validation for a 4-year period for the semi-distributed model. Data sparse condition simulation performed well with 0.84 NSE promising the model prediction capability under limited weather data. Most importantly, X1 to X4 four parameters of the GR4H model do not show significant variation comparing densely gauged catchment and sparsely gauged catchment. This hydrological modelling process is critical in data-sparse areas but not limited to ungauged catchments.

Keywords: GR4H; Flood; Modelling; Forecasting; Ungauged

ICSBE 2023-286

TRANSFORMING HOUSING RETROFIT: THE POTENTIAL IMPACT OF ARTIFICIAL INTELLIGENCE

C, Panakaduwa[1*], S,P, Coates[1], M, Munir [1]

[1]University of Salford, United Kingdom.

**Correspondence E-mail: c.s.panakaduwagamage@edu.salford.ac.uk*

Abstract: 80% of the housing stock by 2050 in the UK has already been built. Currently, the UK housing stock contributes 18% of the total UK emissions. Due to the legal requirement of the UK government to achieve net zero by 2050, the housing stock poses a considerable challenge to achieve this objective. Accordingly, reducing the energy demand of the housing stock through sustainable retrofit is a key priority. However, various reasons have been slowing down the progress of housing retrofit in the UK. Artificial intelligence [AI] has become a contemporary buzzword due to the emergence of GPT and its use in different industries. Considering the above, this study first sets out to identify how AI can establish improvements in current processes. Secondly, it identifies what areas can be best optimised with AI. A literature review was conducted to establish the existing retrofit processes and to understand the potential of AI. Thereafter, an empirical study was conducted using semi-structured interviews with software engineers involved in AI to find the potential of AI in housing retrofit. The findings of the study mainly benefit policymakers, homeowners, retrofit professionals and construction companies. Considering the dire need to push housing retrofit forward to achieve Net Zero goals, this study can be helpful in developing ideas. However, this study will show only the possible directions for driving retrofit, not an exact solution. The literature suggests that the benefits of housing retrofit are for both the homeowners and the society. Although the benefits to the homeowners are set aside, it is not possible to ignore the sustainability purpose of retrofit as climate change is a documented reality. As the revolution of artificial intelligence is now a reality, the synergy of housing retrofit, and AI is an important opportunity.

Keywords: Artificial intelligence; Energy efficiency; Housing retrofit; Sustainability

COASTAL ENGINEERING

ICSBE 2023-101

EXTREME WAVE ANALYSIS WITHIN A CONFINED HARBOR BASIN: A CASE STUDY OF COLOMBO PORT

D. P. C. Laknath[1*], I.G.I. K. Kumara [1], S.S.D.S Gunasekara[1]

[1]Lanka Hydraulic Institute Ltd, Katubedda, Sri Lanka

**Correspondence E-mail: chanaka.laknath@gmail.com, TP: +94112650409*

Abstract: Designing maritime structures requires calculating design waves for a specific return period. This involves analyzing extreme waves (EWA) using long-term wave data at a specific depth in the sea. Typically, spectral models like MIKE21 SW are used to simulate these long-term wave parameters for EWA. However, when analyzing wave data inside an enclosed coastal area such as a harbor basin, using a spectral wave model may not be suitable due to its limitations in simulating wave processes like reflection and diffraction. Wave heights simulated by MIKE21 SW could be underestimated within the basin due to the influence of structures like quay walls or breakwaters, which affect wave reflection. To address this, our study focuses on EWA within the enclosed basin, utilizing a combination of spectral and Boussinesq wave approaches. Specifically, we selected Colombo Port as our study area and employed the MIKE21 BW module, which can successfully simulate reflection and diffraction processes within the basin. Wave data was hindcast by the MIKE21 SW model at a depth of 20m in the Colombo Sea for the years 1998 to 2015, and continued EWA. Applying the Peak Over Threshold (POT) technique, we extracted wave heights from storms occurring over a 17-year period in Colombo for EWA. We employed the Weibull distribution as the best-fitting function to estimate extreme wave heights for return periods of 1, 5, 10, 25, and 50, considering the goodness of fit. These identified extreme wave heights were then transformed using the MIKE21 BW model to the possible development site inside the Colombo Port basin. To estimate the peak wave period for the identified extreme wave heights within the harbor basin, we utilized the relationship between peak wave period and significant wave heights at a 20 m depth. This information provides valuable insights for possible maritime development within the Colombo Port basin.

Keywords: EWA; Spectral wave; Boussinesq wave, Numerical simulation

ICSBE 2023-102

NUMERICAL MODELLING OF COASTAL PROCESSES FOR ENHANCED NAVIGATION THROUGH NATURALLY FORMED SUBMERGED REEFS

D. P. C. Laknath[1*], I.L. Abeygoonasekara[1], D.E.N. Senarathne[1], K.K.P.P. Ranaweera[2]

[1]Lanka Hydraulic Institute Ltd, Katubedda, Sri Lanka

[2] Ceylon Fishery Harbour Corporation, Sri Lanka

** Correspondence E-mail: chanaka.laknath@gmail.com, TP: +94711400636*

Abstract: Kadamaththa, located in Dehiwala, is a fishery landing site shielded by two naturally formed coral reefs that run parallel to the beach. The existing gap between these two reefs serves as an access point for sea navigation to the fishing landing site. However, despite widening the gap in 1952, navigating through it remains challenging and hazardous, particularly during the southwest monsoon season. This is primarily due to submerged rock formations at the entrance, leading to dangerous wave breaking actions. To address this issue, it was proposed to construct an anchorage (breakwater) on the submerged reefs, along with the removal of rocks within the approach channel area. In light of this proposal, the primary objective of this study was to evaluate the navigability and safety of the anchorage's access point, considering the proposed development on the submerged reef. Numerical simulations were conducted to analyze seasonal coastal processes, including wave disturbances, currents, and sediment transport, both in the existing conditions and with the proposed development. The conceptual layouts for the anchorage were designed based on stakeholder opinions and the assessment of existing coastal processes. To simulate hydrodynamics, sediment processes, and wave disturbances, the MIKE 21 modeling system was employed in this study. The wave disturbances were simulated under representative nearshore wave conditions using the MIKE 21 BW (Boussinesq Wave) model. The MIKE 21 HD (Hydrodynamic) model was utilized to evaluate the hydrodynamics of the anchorage entrance, basin, and surrounding areas. Further, the MIKE 21 ST (Sediment Transport) model was employed to identify sediment transport patterns and the potential for siltation within the anchorage entrance and approach channel. Based on the numerical simulation results, suitability of proposed anchorage layout was concluded, taking into account the navigational and safety considerations identified through the modeling process.

Keywords: Submerged reefs; Coastal process; Simulation; Navigation

ICSBE 2023-106

HARBOUR DEVELOPMENT IN BALAPITIYA: INSIGHTS FROM NUMERICAL MODELING OF COASTAL PROCESSES

D. P. C. Laknath[1*], D.E.N. Senarathne[1], I.L. Abeygoonasekara[1], K.K.P.P. Ranaweera[2]

[1]Lanka Hydraulic Institute Ltd, Katubedda, Sri Lanka.

[2] Ceylon Fishery Harbour Corporation, Sri Lanka.

** Correspondence E-mail: chanaka.laknath@gmail.com, TP: +94711400636*

Abstract: The study focuses on the proposed harbour development in Haraspola Bay, Balapitiya, which benefits from the natural protection of the existing rocky headland on its southern side. Inadequate berthing facilities and unsafe navigational conditions currently hinder efficient fishing activities in the fishing landing site. The conceptual harbour layout considered stakeholder requirements and existing coastal processes to enhance operational efficiency. An accurate assessment of coastal processes is essential to understand their behavior and design harbour layouts with minimal adverse effects from coastal processes. Therefore, this study aims to simulate wave, current, and sediment actions for the proposed harbour, ensuring safe navigation and minimizing adverse effects from coastal processes. The MIKE 21 modeling system was employed for this purpose. Using hindcast nearshore wave climate data, coastal processes were simulated for representative wave conditions. The MIKE 21 BW (Boussinesq Wave) model was utilized to study wave disturbance and ensure that simulated wave heights fall within acceptable limits for safe navigation and mooring operations. The MIKE 21 HD (Hydrodynamics) model results con-firmed the favorable hydrodynamic performance of the proposed harbour configuration. To investigate potential siltation issues, the MIKE 21 ST (Sediment Transport) model was used to analyze sediment transport patterns, particularly at the harbour entrance and approach channel. While sediment transport rates were more significant during the southwest monsoon, the movement of sediment into the harbour through its entrance is limited. Therefore, the proposed harbour layout is expected to facilitate sediment bypass. In conclusion, the numerically simulated results justify the suitability of the chosen harbour location and layout. By considering stakeholder requirements and understanding coastal processes, the harbour design ensures safe navigation, optimizes hydrodynamic performance, and minimizes potential siltation problems. This study highlights the importance of accurately assessing coastal processes in developing a harbour that promotes efficient fishing activities while mitigating adverse effects from waves, currents, and sediments.

Keywords: Harbour development; Coastal processes; MIKE 21; Numerical modelling

ICSBE 2023-196

CHANGE DETECTION FROM 2017-2022 OF MANGROVE AREA AROUND THAMPALAGAM BAY AND ESTIMATION OF CARBON DIOXIDE ABSORPTION OF MANGROVES IN A SELECTED AREA USING GIS AND REMOTE SENSING TECHNIQUES

Jeyapalu Jathushan [1*], V.P.A.Weerasinghe [1]

[1]Department of Zoology and Environmental Management /University of Kelaniya.Kelaniya GQ 11600,Sri Lanka.

**Correspondence E-mail: jeyabalusaimathini@gmail.com, TP: +94788640229*

Abstract: Mangroves are extremely productive ecosystems along the coast that help to mitigate climate change by absorbing carbon dioxide from the atmosphere. Understanding variations in mangrove areas and carbon storage capacity is critical for assessing these ecosystems' resilience and vulnerability to climate change. The aim of this study is to detect changes in the mangrove area around Thambalagamam Bay in Trincomalee, Sri Lanka, from 2017 to 2022, as well as to estimate carbon dioxide (CO_2) absorption by mangroves in an identified area using GIS and remote sensing techniques. The approach incorporates Sentinel -2 multispectral satellite images with a spatial resolution of 10m, as well as the mangrove vegetation index and supervised image classification algorithms. The approaches' accuracy is evaluated using ground truth data and Google Earth Engine. The above-ground biomass measurements were calculated according to the allometric equations of mangrove species and above-ground carbon stock, and CO_2 absorption was calculated using empirical equations. The mangrove vegetation index (MVI) method gives mangrove forest areas of 12.03 km^2, 10.52 km^2, 8.05 km^2, 8.15 km^2, 10.63 km^2, and 7.77km^2 for the years from 2017 to 2022 respectively. The supervised classification using the maximum likelihood classifier (MLC) method gives the forest areas of 12.09 km^2, 10.61 km^2, 8.13 km^2, 8.20 km^2, 10.71 km^2, 7.81 km^2 for the years from 2017 to 2022, respectively. Both methods show similar accuracy over 90%. The extent of mangrove forests shows a decreasing trend from 2017 to 2019 and an increase from 2019 to 2021 which indicates potential recovery and successful conservation measures and again shows a sharp decrease from 2021 to 2022 indicating deforestation. Results of the polynomial regression analysis shows NDVI had the strong correlation ($AGB = 7232 - 20420NDVI + 14482NDVI^2$; r^2 =92.10%) with above-ground biomass (AGB) in the Thambalagamam Bay mangrove forest. Increasing order of total absorbed CO_2 relevant to stratum are Luminetzera racemose (186.195 ton/ha), Multi species (439.858 ton/ha), *Rhizopora mucronate* (453.825 ton/ha), *Avicena officinalis*(675.937 ton/ha), *Avicena marina* (2635.572 ton/ha). Totally, 4391.387 ton/ha CO_2 absorbed by the selected site of mangrove forest around Thambalagam bay. The study highlights the importance of efforts to preserve the long-term survival of mangrove ecosystems in the face of global climate change.

Keywords: Mangrove ; Change detection ; Above-ground biomass (AGB) ; CO_2 absorption ; Climate change

ICSBE 2023- 259

BASIN RESONANCE STUDY FOR COLOMBO SOUTH HARBOR THROUGH LONG-WAVE STUDIES FOR ENHANCED PORT OPERATIONS

D. P. C. Laknath[1*], **I.G.I. K. Kumara** [1], **S.S.D.S Gunasekara**[1]

[1]*Lanka Hydraulic Institute Ltd, Katubedda, Sri Lanka.*

**Correspondence E-mail: chanaka.laknath@gmail.com, TP: +94112650409*

Abstract: The design and construction of breakwaters are effective measures to protect harbors from the impact of wind-generated short waves and swell waves. These structures enable safe and efficient harbor operations. However, the same solution does not adequately address the challenges posed by long waves. Long waves exhibit a high wave period and relatively low wave height, making it easier for them to enter harbor basin through the harbor entrance. Consequently, the harbor may experience oscillations when incoming long waves resonate with the harbor's natural oscillation period. Such oscillations can lead to increased downtime and mooring difficulties, even though other adverse wave effects that have been already successfully addressed for short-period waves. While the scientific literature extensively covers short waves, there has been limited research on long waves and harbor resonance. This study focuses on Colombo South Harbor (CSH), which was designed in 2005 and construction works were completed in 2012. Although basin resonance studies for CSH considered the original terminal arrangement, the east and west terminal are remained incomplete, with plans for completion in future. Consequently, the study of basin resonance for the intermediate period becomes crucial, emphasizing the harbor basin's existing configuration and depths. Our study aims to identify the oscillation modes generated by long waves in CSH using numerical simulation methods, specifically the MIKE 21 BW (Boussinesq Wave) model. Through white noise simulations, we identified the most sensitive frequency bands prone to long waves. Further simulation and analysis of long waves within these identified frequency bands allowed us to discern the natural oscillation modes of the harbor in both the longitudinal and transverse directions, considering the wavelengths and harmonics involved. In summary, our research sheds light on the phenomenon of long wave oscillations of CSH for the existing harbor configuration and depths. By identifying and understanding these oscillation modes, we contribute valuable insights to harbor operations in the face of diverse long wave conditions.

Keywords: Long waves; White noise simulation; Oscillation modes; NOP; Basin resonance

CLIMATE CHANGE

ICSBE 2023-33

ANALYSIS OF THE IMPACT OF THE CLIMATE CHANGE ON STORM SURGES AND GLOBAL EXTREME EVENTS IN THE 21st CENTURY

B. Premaratne[1]*, F. Inam[2]

[1] School of Architecture, Computing and Engineering, University of East London,United Kingdom, E16 2RD.
**E-mail: b.premaratne@uel.ac.uk, TP: +44 7377881326*
[2] Oxford Business College, Executive Principal Office, 23-38 Hythe Bridge Street, Oxford, United Kingdom, OX1 2EP.
**Correspondence E-mai; fawad.inam@oxfordbusinesscollege.ac.uk*

Abstract: An increase in mean sea level rise due to global warming and change in weather patterns drive extreme sea levels such as storm surges as well as likely intensity and the frequency of them. Over the recent period of time, significant effort has been encountered in enhancing the knowledge and identifying the reasons for the unprecedented storm surges in the 21st century. The post-disaster investigations conducted in a number of extreme events around the world such as Atlantic hurricane Katrina (2005), Indian Ocean cyclone Nargis (2008), and North Pacific typhoon Haiyan (2013), have raised the flag that sea level rise due to climate change and increased sea surface temperature may cause a significant effect on increasing of storm surge height and its intensity. The 6th assessment report of the Intergovernmental Panel on Climate Change (IPCC- AR6) states sea level rise is persistent throughout the 21st century and the projected global mean value will be in the range of 0.28-0.55m greater than the contemporary value under low carbon concentration scenario by the year 2100 due to thermal expansion of oceans and the polar glacial ice melting. Further in line with IPCC-AR6, temperature may increase by 1.5°C (higher confidence level) at moderate to high carbon concentration scenarios. This will lead to a likely reduction of return periods of global extreme storm events by the end of the century. i.e. once in a hundred years, extreme events could occur every year. Consequently, it is undeniable according to the projected values of sea level rise and the temperature change, this challenge will be unrelenting. Hence, this paper focuses on the in-depth qualitative analysis of the impact of climate change on storm surges. Global extreme events over the last two decades will also be investigated to figure out how this global phenomenon has enhanced their severity.

Keywords: Storm surge; Climate change; Sea Surface Temperature; Sea level rise; IPCC-AR6

ICSBE 2023-75

SPATIO-TEMPORAL ANALYSIS OF MODIS-BASED LAND SURFACE TEMPERATURE USING GOOGLE EARTH ENGINE (GEE) IN AMPARA DISTRICT

Nuskiya, M.H.F.[1], Zahir, I.L.M.[1], Mohamed Thariq, M.G.[2], Sunethra Thennakoon[3], Iyoob, A.L.[1], Ameer, M.L.F.[1]

[1]Department of Geography, South Eastern University of Sri Lanka, University Park, Oluvil 32360, Sri Lanka .

[2]Department of Biosystems Technology, South Eastern University of Sri Lanka, University Park, Oluvil 32360, Sri Lanka

[3]Department of Geography, University of Sri Jayewardenepura, Gangodawila, Nugegoda 10250, Sri Lanka

**Correspondence E-mail: nuskiyahassan@seu.ac.lk, TP: +94763129900*

Abstract: The comprehension of Earth's surface thermal behavior and its effects on environmental processes hinges on Land Surface Temperature (LST). In Ampara District, the summers bring sweltering heat and cloudy skies, whereas the winters are short, mild, and frequently accompanied by rain and predominantly overcast conditions. The climate in Ampara District remains persistently oppressive throughout the year, with average temperatures ranging from 23°C to 33°C, seldom dropping below 22°C or exceeding 35°C. This study conducts a spatio-temporal investigation of MODIS-based LST patterns, exploring the interplay between LST and Land Use/Land Cover (LULC) using Google Earth Engine (GEE) in 2023. Utilizing MODIS LST data with a spatial resolution of 1 kilometer and a temporal resolution of 1 to 2 days, the analysis incorporates LULC to elucidate the impact of various land types on LST. Results reveal significant fluctuations in daytime LST, reaching peaks from 27.8°C to 41.5°C, 27.6°C to 38.0°C, and 28.0°C to 38.2°C during April, May, and June 2023, respectively. Particularly in April, the highest daytime LST readings occurred on the 23rd, 17th, 15th, and 20th, recording 36.2°C, 34.9°C, 33.6°C, and 33.4°C, respectively. Similar trends were observed in June, with peak LST values on the 26th and 7th, reaching 38.80°C and 33.20°C, respectively. In contrast, January through March displayed the lowest LST values. Despite a Root Mean Squared Error (RMSE) and correlation coefficient (CC) of 0.96 and 0.97, respectively, zonal statistics identified the agricultural sector, particularly paddy cultivation, as the focal point for the most pronounced LST spikes. Various areas, such as residential zones, bodies of water, non-agricultural lands, and forests, exhibited diverse LST values. The research emphasizes the critical role of vegetation in mitigating the impact of LST, especially during peak heat days, offering valuable insights for urban planning, land management, and climate resilience strategies.

Keywords: Thermal; Spatial; Temporal; Zonal statistics, Environment

ICSBE 2023-194

ESTIMATION OF ANNUAL ENERGY PRODUCTION AND DEVICE PARAMETER OPTIMISATION IN SRI LANKAN WAVE CLIMATIC CONDITIONS

B.H.B.P.D. Baddegamage [1*], R.L.K. Lokuliyana [2], S.D.G.S.P. Gunawardane [1], Y.H. Lee[3]

[1]Department of Mechanical Engineering, University of Peradeniya 20400, Sri Lanka

[2]Department of Mechanical Engineering, The Open University of Sri Lanka, Nugegoda 10250, Sri Lanka

[3]Centre for Offshore Wind and Green Hydrogen Ammonia Research, National Korea Maritime and Ocean University, Busan 49112, South Korea

**Correspondence E-mail: pdbvision@gmail.com, TP: +94712313320*

Abstract: Sri Lanka is a country struggling with energy security. Being an island surrounded by sea, achieving a sustainable energy mix with marine renewable energy development is possible. The latest study conducted with international recommended standards for the Sri Lankan wave energy resource has shown that the marine environment around Sri Lanka has moderate wave characteristics with small frequency bandwidth and narrow directionality of sea states, which provide opportunities to wave energy converter developers. This study establishes a foundation for estimating the annual energy production, offering a sample analysis that can serve as a reference for developers aiming to assess the Mean Annual Energy Production (MAEP) at a specific location along the southern coast of Sri Lanka, considering the utilization of an appropriate wave energy converter (WEC) system. Initially, a wave energy resource assessment, which characterizes the wave climate and energy potential, was conducted at a selected site with international specifications. Afterwards, a 150 kW heaving point absorber type WEC was modeled based on the results of the energy resource assessment. The power capture was optimized by choosing the optimum values for the buoy mass and choosing the shape according to the dominant sea state in the selected site. The power absorption was optimized by tuning the coefficients of the spring-mass damper. Furthermore, a latching control was implemented to maximize the available energy harvest. Finally, the MAEP was estimated by computing the energy production for 120 sea states related to Sri Lankan climatic conditions. This research concludes that Sri Lanka's southern coastal region can provide wave energy with a high-capacity factor, which is a positive sign for potential developers.

Keywords: Wave energy; Mean Annual Energy Production; Wave Energy Converter; WEC optimization

ICSBE 2023-267

CLIMATE CHANGE AND PADDY CULTIVATION OF SRI LANKA

P.K Hitige[1], L.Y Hitige [2*]

[1]Sabaragamuwa University of Sri Lanka, Belihuloya, 70140

[2]General Sir John Kotelawala Defence University, Kandawala Rd, Ratmalana, 10390, Sri Lanka

**Correspondence E-mail: lathikahitige@kdu.ac.lk, TP: +94702166491*

Abstract: Anomalous climate change is a widespread topic currently emphasized in most of the studies in the world due to its impacts in many ways. Being an island, the effect of El Nino and La Nina phenomenon and the monsoons have resulted for the occurrence of range of climate variations in Sri Lanka resulting extreme weather conditions including severe floods and droughts. In the other hand, Sri Lanka is a country where agriculture is one of the dominant industries as rice being the staple food. Therefore, in the agricultural sector the paddy cultivation plays a crucial role in providing rice on the requirement to the nation. There are two distinct agricultural seasons; "Yala" (April to September) and "Maha" (October to March) considering the annual rainfall in the country, and, paddy growing takes place in different zones of the country which have mainly divided as dry zone, wet zone and intermediate zone. But, the extreme climate events have directly influenced on paddy cultivation in Sri Lanka challenging the economy of the country. This study aims to suggest the adaptation strategies to overcome the challenges due to varying climate, on paddy cultivation during the above mentioned agricultural seasons and in the different zones in Sri Lanka. The methodology comprises a literature survey on published works that addressed the issues of climate change and paddy cultivation and have presented the adaptation strategies followed which are applicable to Sri Lanka to minimize the negative impacts of climate change on paddy cultivation.

Keywords: Climate change; Monsoons; Paddy cultivation; Economy; Adaptation strategies

INNOVATION IN BUILDING MATERIALS

ICSBE 2023-117

ENHANCING IMPACT RESISTANCE OF MASONRY STRUCTURES WITH FLEXIBLE CEMENTITIOUS POLYMER COATINGS

T.V. Muthukumarana[1], P.L.D.C. Liyanage[1], H.M.C.C. Somaratthna[1*], S.N. Raman[2,3]

[1]Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Ariviyal Nagar, Killinochchi 44000, Sri Lanka.

[2]Civil Engineering Discipline, School of Engineering, Monash University Malaysia, Jalan Lagoon Selatan, 47500 Bandar Sunway, Selangor, Malaysia

[3]Monash Construction Circularity Node (Monash-ConCerN), School of Engineering, Monash [3]University Malaysia, Jalan Lagoon Selatan, 47500 Bandar Sunway, Selangor, Malaysia

**Correspondence E-mail: hmccsomarathna@eng.jfn.ac.lk, TP: +94 718304634*

Abstract: Cement mortar is widely used in masonry construction. Mortar, although possessing good compressive strength, lacks tensile and flexural strength due to its brittle and rigid nature. Consequently, masonry structures are vulnerable to fragmentation when subjected to dynamic loads, ranging from low-velocity impacts to high-impact and high-impulse loads. These loading conditions can lead to loss of life and property damage. However, the existing masonry strengthening techniques aren't capable of absorbing energy during dynamic loading and are not easily accessible or affordable. In this research, the feasibility of utilizing a flexible cementitious polymer coating on masonry structures subjected to dynamic loads was investigated for three coating types (0%, 5%, and 10% of overall thickness) applied on the impact face and rear face of 40×40×160mm mortar prism specimens. Universal Testing Machine (UTM) was used to conduct three-point bending tests with cross-head speeds of 1 and 200 mm/min to simulate quasi-static and impact loading conditions, respectively, resulting in strain rates of 0.00028s-1 and 0.056s-1. The results showed that under dynamic loading, the impact face-coated specimens with a 4 mm thick coating absorbed 119.05% more cumulative energy compared to the control specimens. Moreover, the specimens coated on the rear face displayed a substantial enhancement in energy absorption, particularly when applying a 4mm thick coating, resulting in an 889.83% increment compared to the control specimens, along with a remarkable 1346.72% enhancement in ultimate strain. The polymer coating exhibited favourable adhesion characteristics by remaining bonded to the test specimens during ultimate failure. Even with a minimum coating thickness of 5%, the coating effectively reduced fragmentation effects. The feasibility analysis revealed that employing flexible cementitious polymer coating presented a viable approach to improve the dynamic response of masonry structures. Furthermore, the optimal configuration was determined to be a 10% thick coating applied to the rear face, offering the most favourable arrangement.

Keywords: Flexible cementitious polymer; Impact loads; Masonry structures; polymer coating; Masonry strengthening

ICSBE 202-119

FEASIBILITY OF USING PALMYRA STRIPS AS REINFORCING MATERIAL IN LIGHTLY LOADED CONCRETE BEAMS

R.C. Dissanayake [1], S. Lusiyashtharsikka [1], H.M.C.C. Somarathna [1,2*], B. Kiriparan [1]

[1] Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Ariviyal Nagar, Killinochchi 44000, Sri Lanka.

[2]Department of Civil Engineering, Faculty of Engineering, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka

**Correspondence E-mail: hmccsomarathna@gmail.com, TP: +94718304634*

Abstract: Contemporary development projects have seen a rise in reliance on conventional building materials like steel, prompting global efforts to explore alternative reinforcement options. However, limited technical information on locally available materials has led to consumers relying on readily accessible information about industrialized materials. One potential alternative is Palmyra, a structural timber found in Sri Lanka's northern region. This study aims to evaluate the feasibility of using Palmyra strips as reinforcement material in concrete applications. Initial evaluations involve examining the mechanical properties of Palmyra wood, casting beams with steel reinforcement and Palmyra strips, and subjecting them to four-point bending test. To enhance durability and water resistance, the Palmyra strips were treated with varnish, sand pressing, and a 24-hour drying period. The control specimen had 8 mm diameter steel reinforcements, while the full replacements were 20 mm x 20 mm Palmyra wood strips. For the partial replacement, the top reinforcement was made of 20 mm palmyra wood, and the bottom reinforcement was made of 8 mm diameter steel. Specimens were cured for 28 days. The deflection at the midpoint was measured, and stress-strain curves were generated. The test results showed that the full and partial replacements of steel with Palmyra strips showed up to 9 % reduction of the average maximum strength compared to the control specimens while showing up to 43 % of enhancement in the maximum strain. Correspondingly, an enhancement of the strain energy values at the point of maximum stress was observed in both partially replaced, and fully replaced beams. Cracking is consistently initiated from the bottom, resulting in shear failures. The findings suggest that full and partial replacements of top reinforcement can be adopted in lightly loaded concrete beams with marginal changes in strength capacity while having enhancement in strain and energy absorption capacities.

Keywords: Alternative reinforcement; Concrete beams; Flexural response; Palmyra strips

ICSBE 2023-120

THE USE OF WIRE MESH–FLEXIBLE CEMENTITIOUS POLYMER COMPOSITE FOR STRENGTHENING REINFORCED CONCRETE BEAMS

M.A.V.H.M. Arachchi[1*], S.P.R.S. Jayasinghe[1], H.M.C.C. Somarathna [1,2], D. Mohotti[3]

[1]Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Ariviyal Nagar, Killinochchi 44000, Sri Lanka.

[2]Department of Civil Engineering, Faculty of Engineering, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka.

[3]School of Engineering and Information Technology, The University of New South Wales, Canberra, ACT 2600, Australia.

**Correspondence E-mail:vhmsara@hotmail.com, TP: +94714093515*

Abstract: The study investigates the use of wire mesh-flexible cementitious polymer composite to strengthen reinforced concrete (RC) beams. Control beams having the size of 600mm ×150mm ×150mm, were reinforced longitudinally with four 8 mm TOR steel bars and laterally with six 6 mm mild steel bars. The feasibility of the proposed method was investigated by altering steel mesh layers, employing a flexible polymer and 3 mm wire mesh. Control, one layer, two layers, and three layers of mesh-polymer composite specimens were used to evaluate the effect of different coating arrangements. Following ASTM C293 guidelines, four-point bending test was conducted and the time, load, and deflection were monitored. Findings showed that significant advancements were made by adding more layers of wire mesh. In contrast to the control, the stress and strain capacities were significantly improved, particularly with three layers having the maximum improvements of 121.67% for stress and 194% for strain. The energy at failure and the energy at design stress were similarly enhanced by layering, showcasing up to 5.59 times increased energy absorption capacity. The composite's effectiveness was derived from better load distribution, improved bonding between wire mesh and specimen, and additional mesh support. This combination improved energy absorption and deformation capacity by causing shear fractures instead of flexural tension cracks. The retrofitting method was economical, simple, and required little knowledge or equipment. The composite's effectiveness was derived from better load distribution, improved bonding between wire mesh and specimen, and additional mesh support. This combination improved energy absorption and deformation capacity by causing shear fractures instead of flexural tension cracks. The retrofitting method was economical, simple, and required little knowledge or equipment. The implications for the construction sector are significant, indicating that this method effectively and affordably improves RC beam characteristics. The work contributes to structural engineering by addressing beams using novel techniques such as wire mesh-polymer composite retrofitting and provides a possible option for enhancing the performance and lifespan of existing structures.

Keywords: Wire mesh; Flexible cementitious polymer; Beam strengthening; Flexural characteristics

ICSBE 2023-131

SYNERGISTIC EFFECTS OF GRAPHENE OXIDE – SILICA NANOHYBRIDS ON THE PROPERTIES OF CEMENT MORTAR

Suganthiny Ganesh[1*], S. V. T. Janaka Perera[1], Charitha Thambiliyagodage[2] ,R. K. N. D. Rajapakse[1]

[1] Department of Civil Engineering, Faculty of Engineering, Sri Lanka Institute of Information Technology (SLIIT), Colombo 10115, Sri Lanka

[2] Faculty of Humanities and Sciences, Sri Lanka Institute of Information Technology (SLIIT), Colombo 10115, Sri Lanka

** Correspondence E-mail: Suganthiny.g@sliit.lk*

Abstract: Incorporation of individual nanomaterials, as graphene oxide (GO) and nano-silica (NS), in cement composites improved its properties with some shortcomings. Limitations of individual GO and NS are overcome by graphene oxide- silica nanohybrid (GO/NS) enhancing the overall performance. The study compares the performance of GO, NS and GO/NS in cement mortar, with an addition of 0.03% nanomaterials (w.r.t the weight of cement). Addition of GO/NS improved the 7-day and 28-day compressive strengths by 5.5% and 10.2% compared to NS but dropped by 9.8% and 11.0% relatively to GO. However, the indirect tensile strengths improved by 27.7% and 7.0% compared to NS and GO, respectively. Presence of GO/NS enhanced the durability properties as water absorption, compressive and tensile performance under higher tempertures as 200 ºC, 300 ºC and 400 ºC. Characterization of GO/NS embedded cement mortar illustrated better pore structure based on Brunauer–Emmett–Teller (BET) analysis and showed more calcium silicate hydrate (C-S-H) formation grounded on X-ray Photoelectron Spectroscopy (XRD) analysis.

Keywords: Nanohybrids; Morphology; Durability; Pore Structure; Calcium Silicate Hydrate.

ICSBE 2023-142

BEHAVIOR OF DAMAGED REINFORCED RUBBERIZED CONCRETE BEAMS STRENGTHEN WITH CARBON FIBER REINFORCED POLYMERS

R.K.S. Maleesha [1*], J.C.P.H. Gamage [1], E.R.K. Chandrathilaka [1]

[1]Department of Civil Engineering, University of Moratuwa, Sri Lanka

**Correspondence E-mail: rksmaleesha@gmail.com, TP: +94713501541*

Abstract: Developing rubberized concrete (RuC) for structural applications is an excellent solution for the scarcity of natural aggregates and the discharge of rubber waste in bulk volumes into the natural environment. With the successful applications of rubberized concrete in structural elements, it is important to explore successful alternatives for restoration in case of deficiencies met in their service life. This study investigates the flexure behaviour of damaged reinforced rubberized concrete beams strengthened with Carbon Fiber Reinforced Polymer (CFRP) fabric. A total of four medium-scale non-strengthened reinforced rubberized concrete beams and a normal concrete beam were preloaded until a 0.3 mm crack occurs. Then the damaged beams were strengthened using CFRP with and without polymer anchors at the ends of the bonded fabric. Four-point bending test was conducted subsequent application of cyclic load with the amplitude of 50% and 75% of the ultimate load. CFRP-strengthened reinforced rubberized concrete beams could reach a 53% higher load with 61% less displacement until a 0.3 mm crack occurs than non-strengthened reinforced RuC beams. It was found that the U-wrap end anchorage system increased the ultimate load by 5% than without end anchorage, delaying the debonding of CFRP fabric. Strengthened RuC beams also showed a similar load-displacement curve pattern as normal concrete beam. Overall, the experimental results exhibited the feasibility of strengthening rubberized concrete beams in structural applications with CFRP fabric.

Keywords: Rubberized concrete; Damaged concrete beams; Cyclic load response; Flexural strength; CFRP

ICSBE 2023-229

THE SUCCESS OF SUSTAINABLE MATERIALS IN CREATING SUSTAINABLE BUILT ENVIRONMENT: AN INSIGHT FROM LOCAL CONSTRUCTION PRACTICES

G.W.J.K.K. Wijesundara

School of Architecture, Sri Lanka Institute of Information Technology

jeeva.w@sliit.lk, TP: +94 71 521 4382

Abstract: The built environment is accountable for most global greenhouse gases and raw material extraction. Mere replacing old structures with new ones would not improve the climate efficiency of the built environment. Both the construction and operation of a building cause a vital resource and energy consumption which significantly impact the environment. The practice today along with the academia has admitted the use of sustainable materials as a key approach in creating a sustainable built environment. The major objective of this study is to find out the ways of retaining the value of resources and preventing the use of non-biodegradable materials and waste outputs. The scope includes investigating the potential of recyclability, and reusability of construction materials and reducing the need for resources. Live examples performed by experts in the industry; eminent architects and engineers were studied for minimalistic materiality. The conclusions raise the strategies used simultaneously to retain the aesthetics and sustainability of the built environment while keeping the strength of the structures ensuring the lifespan.

Keywords: Built environment; Sustainable materials; Resources; Recyclability; Reusability

ICSBE 2023-241

GYPSUM BOARD REINFORCED WITH PINEAPPLE LEAF FIBER

T.P. Jagoda[1*], K.M.C. Konthesingha [1], S.M.A. Nanayakkara [2], P.M.W.P. Kumara [1], H.M.S.C. Rathnasiri [1], I.R. Upasiri [1], W.P.H.P. Weerasinghe [1], A. Branavan [1]

[1] Department of Civil Engineering, University of Sri Jayawardenepura, Colombo 10250, Sri Lanka

[2] Department of Civil Engineering, University of Moratuwa, Moratuwa, Western Province, Sri Lanka

**Correspondence E-mail: piumithakshilajagoda@gmail.com, TP: +94766514129*

Abstract: Renewable materials play a vital role in the green construction approach where they help to reduce carbon footprint and enhance the life of building structures. These materials, derived from natural sources such as timber, bamboo, straw, cork, pineapple leaf, tapioca stalk and recycled materials, offer numerous advantages over recent construction materials. There is much research on using natural fibre as a renewable material to reinforce concrete. Furthermore, many research was conducted on using natural fibres to reinforce gypsum plasterboards. No more research has been conducted on using PALF (Pineapple leaf fibre) to reinforce gypsum plasterboards which is a locally available material. Therefore, this research was focused on reinforcing gypsum plasterboard with PALF. Manufacturing gypsum plasterboards by reinforcing with PALF is a significant step in adopting renewable materials to the construction industry. A gypsum fiberboard is a reinforced material consisting of gypsum and cellulose fibres. Fibrous materials such as cellulose or glass fibre are added to gypsum to improve their mechanical properties. This study mainly uses PALF as a renewable material to manufacture interior fibre-reinforced gypsum panels. As reinforcement fibres in plastic matrices, Pineapple Leaf Fiber (PALF) has shown its significant role by being cheap and exhibiting superior properties. In this research, pineapple leaf fibre was extracted, and treated and then the PALF-reinforced gypsum boards were created. The dimensions were checked ensuring the ASTM codes. The density, flexural strength test and surface hardness test had been conducted for PALF-reinforced gypsum panels. The proportion of fibre used for the testing was 0%,0.5%, 1%, 1.5% and 2%. The research identifies that an optimum of 1.5% of fibre proportion enhances flexural strength and the surface hardness of the PALF-reinforced gypsum boards increased with the fibre percentage.

Keywords: Fibre-reinforced gypsum panels; PALF; Renewable materials; Sustainable material; flexural strength

BRIDGE DESIGN CONSTRUCTION AND MAINTENANCE (ORGANIZED BY THE IABMAS SRI LANKA GROUP)

IABMAS 2023-73

ROTATIONAL FLEXIBILITY OF DOUBLE-ANGLE RIVETED BRIDGE CONNECTIONS

B Imam[1*], N Burud [1], M K Chryssanthopoulos [1]

[1]School of Sustainability, Civil & Environmental Engineering, University of Surrey, Guildford, Surrey, GU2 7XH, UK.

**Correspondence E-mail: b.imam@surrey.ac.uk, TP: +44 1483 689679*

Abstract: Double-angle riveted connections are typically present in riveted bridges joining various bridge members together. Their moment-rotation characteristics are important within the context of their fatigue assessment as the degree of their rotational flexibility can directly influence the level of stresses developed on the members as well as in the connection itself. This paper outlines the development and analysis of a detailed finite element (FE) model of a typical double-angle connection and its calibration to correlate the theoretical analysis with experimental data. Further parametric analysis of the calibrated FE model is then carried out to understand the rotational flexibility of other typical connection types and configurations found in typical metallic riveted half-through bridges. The connection stiffness was found to be sensitive to the presence of even slight clearances between various connection components. The overall results obtained demonstrate a large degree of variability in the rotational flexibility values of the connections investigated.

Keywords: Riveted connections; Rotational stiffness; Fatigue assessment; Experimental testing, Numerical analysis

IABMAS 2023-181

STEEL TRUSS BRIDGE WITH BUCKLING RESTRAINED DAMPERS UNDER SEISMIC LOADING

E. Yamaguchi[1*], N. Enkhbold [1], P. Sosorburam [2]

[1]Kyushu Institute of Technology, Kitakyushu, Japan

[2]Mongolian University of Science and Technology, Ulaanbaatar, Mongolia

**E-mail: yamaguch@civil.kyutech.ac.jp, TP: +81-93-884-3110*

Abstract: There are quite a few bridges designed by the old design codes in Japan. Many of those bridges may not be satisfactory for the current seismic design codes. The behavior of a steel truss bridge under a large seismic loading is investigated by the nonlinear dynamic finite element analysis in the present study, and indeed some members are found possibly damaged by the earthquake. The buckling restrained bracing (BRB) is widely used to improve the seismic behavior of a building. On the other hand, its application to a bridge is very limited. The BRB device may also be used as a damper rather than a structural member, in which case the device may be called a buckling restrained damper (BRD). Yet, such application has not been studied well. In the present research, the application of the BRD is tried. A parametric study on the seismic behavior of a steel truss bridge with BRDs is conducted by changing the length and the cross-sectional area of the yielding core of the BRD. The influence of the locations of BRDs is also considered. The study concludes that with the application of well-designed BRDs to appropriate locations, a steel truss bridge could go through a large earthquake without damage.

Keywords: Buckling Restrained Damper; Steel Truss Bridge; Seismic Damage; Nonlinear Dynamic Analysis

IABMAS 2023- 182

LOAD TESTING AND RATING OF A PC BRIDGE WITHOUT STRUCTURAL PLANS

C. Hutchinson[1*], A. Peiris[1], I. Harik[1]

[1]University of Kentucky, Lexington, KY, USA

**Correspondence E-mail: Cody.Hutchinson@uky.edu*

Abstract: Located in Spencer County, Kentucky, USA a 202.7 m (665 ft) 7-span prestressed concrete bridge carries KY-248 over Little Beech Creek. Constructed in 1981, this bridge has no available structural plans and has a gross load posting of 20 tons (22 US tons). This paper details the assumptions and methodology used to determine the safe live load capacity of the bridge utilizing diagnostic load testing. The load testing program and load rating were performed in accordance with the AASHTO Manual for Bridge Evaluation. This method involved conservative assumption of the prestressing, development of a 2D Finite Element model, and adjustment of the model results based on field measured strain data. Despite a lack of structural plans, the rating methodology used allowed for a conservative confirmation that the bridge has sufficient capacity to support legal traffic without restriction.

Keywords: Prestressed Concrete; Load Testing; Load Rating; Bridge Test

ICSBE 2023-132

EVALUATION OF THE DEGREE OF UNCERTAINTY IN ASSESSING DETERIORATED PC I-BEAM END CAPACITY

S. K. Bhowmik[1*], Y. Hu[1], U. B. Attanayake [1]

[1]Department of Civil and Construction Engineering, Western Michigan University, Kalamazoo, Michigan 49008-5316

**Correspondence E-mail: sanjoykumar.bhowmik@wmich.edu, TP: +12692763207*

Abstract: One significant issue that greatly impacts existing prestressed concrete (PC) bridges is the deterioration of the girders' end sections. This deterioration is primarily attributed to the leakage of expansion joints, which allows water, de-icing chemicals, and contaminants to reach the girder ends. The decision-making process for determining whether to undertake preventive maintenance, rehabilitation, or replacement of the damaged girder is often challenging due to lack of guidelines and procedures for quantifying damages and reliable capacity assessment methods. To overcome this challenge, a PC I-beam end damage classification was developed based on a comprehensive literature review, an analysis of the Michigan bridge database, and the data collected during beam end repair. The damage classification includes quantitative categorization of corrosion in prestressed strands and stirrups, cracking, delamination, spalling of concrete, and loss of bearing area. The primary concern regarding beam end deterioration is focused on shear capacity deficiencies. Therefore, the available shear capacity calculation models, such as the sectional design method and the Strut-and-Tie Modelling (STM) method, were evaluated against the defined damage classification. The impact of uncertainties in damage quantification on the beam end capacity calculation was examined and the level of confidence for using each capacity calculation model was established. The outcome is a set of recommendations for improving beam end inspection procedures and a framework to support preservation and maintenance decisions.

Keywords: Damage assessment; girder end region; prestressed concrete bridges; sectional design; shear capacity; strut-and-tie model

IABMAS 2023-148

POSTTENSION MODELLING TECHNIQUES FOR A TIE GIRDER OF A NETWORK TIED ARCH BRIDGE

B. M. K. L. K. Basnayake[1], U. B. Attanayake [2*]

[1]Parsons Corporation, CT USA

[2]Western Michigan University, Kalamazoo, MI USA

**Correspondence E-mail: upul.attanayake@wmich.edu*

Abstract: Posttensioning (PT) is a form of prestressing of concrete members to increase its tensile load capacity. The process includes (i) installing tendons inside plastic or steel ducts embedded in concrete, (ii) pulling tendons from one or both ends up to a predefined force after concrete attains a specified strength for the operation, and (c) anchoring the ends to maintain the required force in the tendons. Ducts are typically grouted to enhance durability and establish strain compatibility between tendons and the surrounding concrete. Due to wobbling effect and friction, the force along the tendon decreases during the jacking operation. Further, the force in the tendon is slightly reduced during anchoring. Different modelling techniques are used to represent the stress state in posttensioned concrete members. One such approach is to embed the tendons in 2D or 3D structural elements representing the concrete member by excluding the influence of the ducts. With this modelling approach, the gross cross-section area of the concrete member is used to calculate stresses. This can be a concern when empty ducts are present during multi-stage posttensioning. A common technique implemented in commercial software is to model the concrete member using 1D line elements with the posttensioning force applied as member loads. As a more precise approach, a refined 3D finite element model with proper representation of empty ducts and grouting sequence can be developed. However, this approach also presents several challenges such as the simulation of tendon force variation along its length. The posttensioning of an instrumented tie girder in a tied network arch bridge is used as a prototype to evaluate different modelling techniques. Strain measurements recorded during posttensioning of the tie girder are used to validate the models. The paper describes different modelling approaches and their capabilities and limitations to represent the stress state of concrete members.

Keywords: Finite element modelling, Network tied arch bridge, Posttension modelling, Posttensioned concrete tie girder

IABMAS 2023-134

ULTIMATE LOAD CAPACITY OF SUSPENSION BRIDGE AT MALIBADA, SRI LANKA

R.C.S. Jinadasa[1], P.A.K. Karunananda [1*]

[1]Department of Civil Engineering, The Open University of Sri Lanka, Nawala, SRI LANKA

** Correspondence E-mail: pakar@ou.ac.lk, TP: +94718385810*

Abstract: Malibada suspension bridge which was constructed in 1919, is located closed to Daraniyagala in Kegalle district Sri Lanka. It consists of two towers and four cables. The bridge currently displays deteriorated conditions due to corrosion, and the alignment of one cable has been changed from the original design condition. Firstly, all the site measurements were determined, including the geometric details of the bridge span (81m), bridge width (0.85m), tower height (9m), cable diameters (35mm), and the dimensions of all steel elements. Secondly, Brinell hardness tests were performed on the bridge members, and ultimate tensile and yield strength values of the members were determined using these hard-ness measurements. The actual dimensions and strength properties were used to develop a finite element model using CSIbridge software. The obtained design member forces were compared with the present strength values determined by Brinell hardness measurements. The finite element model analysis was carried out under the initial conditions (with four wire cables) of the existing Malibada bridge using Eurocode load combinations. The results have shown that 1kN/m2 can be accommodated by the bridge. Hence, 38 Number of people can be accommodated by the bridge at the same time. The next analysis was carried out under the existing physical conditions of the Malibada bridge (one cable broken condition) under Eurocode load classifications. The obtained results indicate that 0.5kN/m2 is the possible maximum load capacity of the bridge. As per observations and results, it is recommended to replace the broken cable of the bridge and repair corroded steel sections in the towers and deck, as it will be able to increase the number of pedestrians. The results would be useful for the local authorities for future renovations of the bridge as well as for the villagers who cross the bridge daily.

Keywords: Suspension bridges; Hardness; Numerical modelling; Ultimate load capacity

IABMAS 2023-135

ADDRESSING SUSTAINABILITY THROUGH INNOVATIVE MIX DESIGNS AND IMPLEMENTATION OF ACCELERATED BRIDGE CONSTRUCTION TECHNIQUES

B. M. K. L. K. Basnayake[1], U. B. Attanayake [2*], M. LaViolette[3], P. Pakala[4], R. Goniwiecha[5]

[1]Parsons Corporation, CT USA

[2]Western Michigan University, Kalamazoo, MI USA

[3]HDR Inc., Omaha, NE USA

[4]Michigan Department of Transportation, Lansing, MI USA

[5]Superior Materials LLC, Farmington Hills, MI USA

**Correspondence E-mail: upul.attanayake@wmich.edu*

Abstract: Concrete is the world's most used construction material (after water). However, the production of portland cement, the most critical ingredient of concrete, significantly contributes to greenhouse gas production. Actions taken by the concrete industry to reduce the carbon footprint of cement and concrete during its life cycle include optimising the concrete mix design, using performance-based innovative concrete mixes, using alternative fuels, implementing carbon capture techniques, and the reuse and recycling of concrete. At present, the concrete industry in the United States is aiming to produce carbon-neutral concrete by the year 2050. All of these efforts are intended to address the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015. Sustainability principles can be incorporated during the design, construction, and maintenance of highway infrastructure projects. The use of accelerated bridge construction (ABC) techniques significantly reduces traffic delays and out-of-distance travel resulting in resource conservation and reduced emissions. The design and construction of the new network tied arch bridge in Michigan is an exemplary project with multiple contributions to achieving SDGs. The post-tensioned concrete members of the bridge were designed and optimised with the use of an innovative high-strength concrete mix. The cement content was limited to 33% while the rest of the cementitious material content was constituted of ground granulated blast furnace slag (40%) and class F fly ash (27%). In addition, user costs and harmful greenhouse gas emissions were reduced with the implementation of ABC techniques. The presentation will describe design and construction aspects of the project and the steps taken to achieve SDGs.

Keywords: Carbon footprint; Performance-based concrete mixes; Supplementary cementitious materials; Sustainable development goals

IABMAS 2023-191

DEVELOPMENT OF EARTHQUAKE RESISTANT DESIGN GUIDELINES FOR BRIDGES IN SRI LANKA

M.A.C. Kumara[1*], C.S. Lewangamage [2]

[1]Road Development Authority,Executive Engineer's Office,New town, Embilipitiya.

[2]University of Moratuwa, Katubedda,Moratuwa

**Correspondence E-mail: kumararda1@gmail.com, TP: +94773791527*

Abstract: With recent seismic events in and around the island, Sri Lanka can no longer be deemed safe from seismic threats. Currently, there are no specific seismic design guidelines available for bridge design in Sri Lanka. Therefore, this study aims to formulate earthquake-resistant design guidelines for bridges in Sri Lanka. To formulate these design guideline, the study proposes a classification of bridges into three distinct importance classes. This classification draws from relevant categorizations found in comparable codes such as EN 1998-2:2005 , IS 1893-3:2014 and AS 5100.2-2004. The proposed importance factors and return periods are based on the guideline outlined in EN 1998-1:2004. Furthermore, the study suggests the adoption of elastic response spectrum for rock or hard soil based on available data specific to Sri Lanka. For medium and soft soil types, it is recommended to utilize the response spectrum available in IS 1893-1:2002. This choice is grounded in the similarity between soil and rock types in countries situated on the same tectonic plate. The study introduces a seismic analysis approach for bridges, offering the option to use either EN 1998-2:2005 or AS 5100.2-2004. Additionally, it proposes suitable design parameters, including peak ground acceleration values, to be selected based on the available national data. Three case studies were conducted to exemplify the application of the developed guidelines for bridges in different important classes. These case studies utilized the design codes of AS 5100. 2-2004, IS 1893-3:2014, and EN 1998-2:2005. Notably, When Eurocode 8-part 2 served as the basis of analysis, both the fundamental mode method and response spectrum analysis yielded similar results in terms of fundamental period and base shear values. Given the flexibility provided by Eurocode 8-part 2 to incorporate national choices, this developed guideline with national parameters, stand as a viable option for the seismic bridge design in Sri Lanka.

Keywords: Bridge design; Importance factors; Intra-plate earthquake; Seismic design guidelines

IABMAS 2023-247

A COMPARATIVE STUDY ON APPROACHES TO ESTIMATE LATERAL DISTORTIONAL BUCKLING STRENGTH IN STEEL-CONCRETE COMPOSITE BEAMS

W. M. A. D. Wijethunge[1 *], A. J. Dammika[1], C. S. Bandara[1], J. A. S. C. Jayasinghe[1]

[1]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Sri Lanka.

**Correspondence E-mail: akilawijethunge@eng.pdn.ac.lk, TP: +94717653085*

Abstract: In multi-span continuous Steel-Concrete Composite bridges, negative moments are encountered over interior supports, causing compression in the bottom flange and a segment of the steel web. If the web of the steel profile lacks sufficient stiffness to resist lateral bending, it may deform, allowing the compressed flange to displace laterally and twist. This is a common phenomenon in Steel-Concrete Composite Beams (SCCBs) subjected to negative moments, which characterises a buckling mode known as Lateral Distortional Buckling (LDB). Various studies have been conducted to enhance our understanding of LDB behaviour in SCCBs. These studies can be categorised into two main research directions. The first involves calculating the elastic critical moment through studies into the elastic behaviour of LDB using bifurcation equilibrium analyses. The second direction delves into the LDB strength of SCCBs through experimental studies or nonlinear numerical analyses. It is noteworthy that discrepancies exist among the formulas presented in the literature for calculating the elastic critical moment. Additionally, variations exist in conventional approaches to assess LDB strength. This demonstrates that LDB is a form of in-stability that the structural engineering research and design community has yet to fully comprehend. Therefore, the primary focus of this study is to assess the performance of SCCBs and offer a comparative analysis of theoretical and standard methodologies for evaluating LDB strength. To accomplish this, Finite Element (FE) models of SCCBs were developed using the FE software package Abaqus 2021, accounting for geometric imperfections and material non-linearity. The FE models accurately predicted the ultimate moment capacity of SCCBs, demonstrating excellent agreement with experimental results with a maximum relative error of less than 2%. In contrast to conventional approaches, the study's findings revealed significant disparities in ultimate moment estimation. These in-sights can significantly contribute to upcoming discussions related to bridge research and specification enhancements.

Keywords: Steel-Concrete Composite Beams; Elastic Critical Moment; Negative moment; Lateral Distortional Buckling; Nonlinear Finite Element analysis

IABMAS 2023- 257

FINITE ELEMENT MODELLING OF DUCTILE FRACTURE BEHAVIOUR OF THICK-WALLED STEEL HOLLOW BOX PIERS UNDER LATERAL CYCLIC LOADINGS

A. C. D. Pigera[1*], M. Jenothan [1], J. A. S. C. Jayasinghe [1], C. S. Bandara [1], A. J. Dammika [1]

[1]Faculty of Engineeering, University of Peradeniya.

**Correspondence E-mail: e16283@eng.pdn.ac.lk, TP: +94778116448*

Abstract: Thick-walled steel box type piers are widely used in bridge structures due to their ductility and resistance to seismic loadings. These structures are designed to withstand both lateral and vertical loads. Both the static and cyclic loads are applied on these structures. Unlike the thin-walled counterparts of these structures where local buckling of plates governs, main failure mode observed in thick-walled structures are initiation and propagation of ductile fractures. Number of experimental studies have been carried out to investigate the ductile failure behaviour of these structures under lateral cyclic loadings, but estimation of the failure behaviour by numerical approaches is limited. Therefore, the focus of this study is to develop a comprehensive numerical model which can accurately predict the ductile failure modes of thick-walled steel box piers under lateral cyclic loading conditions and validate the model using available experimental data from the literature. Element deletion feature under ductile damage in nonlinear finite element software ABAQUS was used for the simulation of ductile crack initiation and propagation. Results revealed that the developed numerical model can accurately predict the locations where the ductile cracks initiate and the direction of the crack propagation.

Keywords: Box Piers; Cyclic Loading; Ductile Damage Model; Finite Element Modelling

IABMAS 2023-361

EXPERIMENTAL INVESTIGATION OF DYNAMIC BEHAVIOR OF PRESTRESSED CONCRETE BRIDGE GIRDERS

G.B. Dissanayake *, A.J Dammika, C.S. Bandara, J.A.S.C Jayasinghe, P.B.R. Dissanayake

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

**Correspondence E-mail: gihanashantha@gmail.com*

Abstract: This paper presents observations of an experimental study of dynamic behavior of prestressed concrete bridge girders. In practice it is often necessary to monitor the condition of bridges for maintenance to ensure safety conditions. Given the fact, bridges are larger, complex in nature and its operating environment is hostile, non-destructive, modal parameter-based techniques outperform the conventional damage detection and health monitoring techniques. However, prerequisite of baseline data of undamaged structure has been one of a major drawback hindering the modal parameter-based technique from effective use. Thus, in this study, the modal frequency and damping behavior of newly cast prestressed concrete girders is investigated. Experiments and subsequent analysis revealed that the effect of magnitude of the prestress force on natural frequencies of standard prestressed bridge girders is minimal, as opposed to some of the literature suggested. Hence, the natural frequencies of standard pre-stressed concrete girders can be determined through a linear elastic beam theory with an equivalent moment of area of the composite section. The damping behavior of prestressed girders could be modelled by viscous type of damping when undamaged condition. The observed damping was varying between 0.4% to 0.8%. Well approximated analytical prediction of damping could be possible using damping prediction formula for reinforced concrete beams.

Keywords: (Pre-stressed concrete girder; Natural frequency; Modal damping; Damage detection; Experimental modal analysis)

IABMAS 2023-362

ENGINEERED CEMENTITIOUS COMPOSITE BEAMS IN IMPACT DAMAGE MITIGATION FOR BRIDGE PIERS

Kasun Wijesooriya[1], Shiyao Zhu [1], Sanket Rawat[3], Chi-King Lee[1], Damith Mohotti[1,2*]

[1]School of Engineering and Technology, The University of New South Wales, Canberra, ACT 2600, Australia.

[2]School of Civil, Mining and Environmental Engineering, Faculty of Engineering and Information Sciences, University of Wollongong, Wollongong, NSW, Australia

[3]School of Engineering, Design and Built Environment, Western Sydney University, NSW 2751, Australia

**Correspondence E-mail: d.mohotti@unsw.edu.au, TP: +61251145160*

Abstract: Barge collisions pose a potential threat to bridge structures spanning navigable waterways. To enhance the protection of these bridges, the design of bridge piers should incorporate specific measures to withstand the impact caused by such collisions. Engineered Cementitious Composites (ECC) hold promise; however, they remain under-researched, particularly in the context of low-velocity impacts, which this manuscript aims to investigate. Steel-polyethylene (PE) hybrid-fibre-reinforced ECC beams, with dimensions of 100mm x 150mm x 1600mm, were subjected to low-velocity vertical impact loading. The beams underwent a low-velocity impact test using a 320kg drop tower. The results demonstrate that ECC beams exhibited reduced deflection and fragmentation on the tension face compared to normal reinforced concrete beams. Moreover, there is minimised formation of cracks on the tension face, along with a reduction in local scabbing at the point of impact. Notably distinct failure modes were observed between the nominal concrete beam and the ECC beams, which are thoroughly discussed in this manuscript.

Keywords: Bridge Piers; Engineered Cementitious Composites; Polyethylene and Steel fibre; Impact loading; Low-velocity Impact

WATER POLLUTION AND WATER TREATMENT TECHNOLOGIES

ICSBE 2023-21

USE OF BULKING AGENTS FOR COMPOSTING SECONDARY SEWAGE SLUDGE FROM WASTEWATER TREATMENT PLANTS; A REVIEW

S.V. Chandeepa[1*], C.S. Kalpage [1]

Department of Chemical and Process Engineering, University of Peradeniya, Peradeniya, Sri Lanka.

**chandeepa.vihangi@gmail.com, TP: +94702578314*

Abstract: Due to the increasing number of centralized sewage treatment plants, the sludge generation has increased in recent years and the disposal has become a serious problem. Sewage sludge is a biodegradable residue which contains large amount of organic matter. Although the sewage sludge is rich in organic matter, the presence of pathogenic microorganisms, toxic heavy metals and organic micro-pollutants restrict its use in field applications. Composting is a feasible solution for sludge disposal. However, high moisture content and low C/N ratio make sewage sludge composting a difficult task. Therefore, additional processes such as composting with bulking agents are proposed. Bulking agents are additional materials which can adjust the moisture content, C/N ratio as well as the porosity of the sewage sludge. With the help of bulking agents, the sewage sludge can meet the optimal conditions for composting and this makes the sewage sludge as compostable. This paper reviews the effects of different bulking agents on composting of sewage sludge and how each bulking agents differ from each other. Also different composting methods that can be used to compost sewage sludge and composting conditions are discussed. Further, modifications recommended for improve performances of bulking agents are discussed.

Keywords: Sewage sludge; Composting; Bulking agents; NH_3 emission; Water absorbability

ICSBE 2023-86

SIMULTANEOUS ELECTROCOAGULATION AND ELECTROCHEMICAL OXIDATION FOR REMOVING NATURAL ORGANIC MATERIALS FROM WATER

B. U. Kaushalya, P. V. Kahawearachchi, H. G. S. S. U. Priyankara, K. G. N. Nanayakkara*

Faculty of Engineering, University of Peradeniya.

**Correspondence E-mail:: nadeen@eng.pdn.ac.lk, TP: +94713008007*

Abstract: In this research, an anode was developed to remove humic substances in water using simultaneous electrocoagulation (EC) and electrochemical oxidation (EO). The anode was modified by electroplating copper on aluminium rods. Synthetic water samples consisting of humic acid were tested for dissolved organic carbon (DOC) removal efficiency. A DOC removal efficiency of >99.9% was achieved by the Al/Cu anode under the reaction time of 60 minutes at a 10 mA/cm^2 current density, which was an increase of 54.8% compared to the Al anode. A similar study using a non-modified Cu anode exhibited a removal efficiency of 20.8%, a further decrease of 54.0% compared to the Al anode. In addition, the energy consumption of 18 kWh/m^3 was recorded by the Al anode, while the Al/Cu anode only consumed 13 kWh/m^3. Finally, natural water samples obtained from the *Padaviya*, Sri Lanka, were tested for DOC removal, which removed 80.4%, and 44.6% of DOC by the Al/Cu anode and the Al anode, respectively. The copper and aluminium leaching into the effluent and the sludge were also analysed. The findings suggest that both EC and EO processes simultaneously contribute to the high removal of NOM when using the novel anode in the electrochemical cell.

Keywords: Advanced Oxidation; Electrochemical Oxidation; Electrocoagulation; Humic Acid; Natural Organic Matter

ICSBE 2023-110

MODELLING SIMULATION OF ELECTROCHEMICAL CELLS FOR WATER TREATMENT

H.G.S.S.U. Priyankara*, T.R.E.A.H.D. Rajapaksha, K.G.N. Nanayakkara

Faculty of Engineering, University of Peradeniya.

**Correspondence E-mail: e16299@eng.pdn.ac.lk, TP: +94766563186*

Abstract: Electrochemical technologies are a promising alternative for the treatment of water and wastewater containing various types of pollutants. There are different electrochemical treatment methods that are used for water treatment to introduce new economically efficient solutions to water and wastewater treatment challenges. To evaluate the performance of electrochemical methods, reactor behavior can be studied by varying physical parameters and operating conditions of the electrochemical reactors. Most of the literature are based on experimental studies to evaluate the reactor behavior. Although computational modelling is an effective method for a better understanding of reactors, scaling up of reactors, etc. it is lacking in the literature. Therefore, this research was focused on developing computational models to understand the reaction behavior of disinfection of E. coli and E. faecalis in ballast water through the electrochemical oxidation process based on data published in previous research studies. Aquasim software (Version 2.1g) was used to develop the reaction models. The software helps to develop the system from initial modelling to advanced simulations. Final concentration profiles and reaction rate constants were derived. The reaction rate constant was reduced with the increase of the initial concentration of the considered bacteria for the developed reactor. The reaction rate constant of the pilot scale reactor did not follow the trend indicating the scale-up effect.

Keywords: Electrochemical Oxidation; Reaction Modelling; Concentration Profile; Reaction Rate Constant

ICSBE 2023-184

A CRITICAL REVIEW ON MICROPLASTICS ABUNDANCE IN MUNICIPAL WASTEWATER

I.W.S.S.Dayananda[1], K.G.N.Nanayakkara[1]

[1]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya.

**Correspondence E-mail: e15060@eng.pdn.ac.lk, TP: +94771815097*

Abstract: Microplastics have become one of the main causes of global water contamination. Wastewater treatment plants (WWTPs) have a dual function in this problem since they are both barriers to preventing the spread of Microplastics and sources of Microplastics in freshwater ecosystems. This is primarily because typical WWTPs are not built with the removal of Microplastics as their primary goal in mind. Since typical WWTPs treat most municipal wastewater, it is essential to concentrate on determining the prevalence of Microplastics in this setting .The objective of this literature review is to obtain an understanding of the opportunities and difficulties related to microplastic (MP) removal within the framework of traditional wastewater treatment. In this extensive literature study, firstly, the characteristics of Microplastics found in municipal wastewater were investigated and the effectiveness of various WWTPs in eliminating these pollutants was evaluated. Furthermore, this study has explored MP forms, dimensions, and abundance at primary, secondary, and tertiary treatment phases within WWTPs. By rigorous inspection and analysis, it is desired to identify the most prevalent types and size ranges of Microplastics found in municipal wastewater treatment systems. This review has shed light on the current condition of MP contamination in municipal wastewater and the effectiveness of existing WWTPs in resolving this issue by compiling and assessing the results from a variety of studies. The outcomes of this study will guide future initiatives to reduce the release of Microplastics into freshwater settings, protecting aquatic ecosystems and public health. They will also help identify possible technologies for improving MP removal.

Keywords: Microplastic; Municipal; Wastewater; Water treatment

ICSBE 2023- 185

CASE STUDIES OVER THE FAILURE OF ONSITE SEWERAGE TREATMENT SYSTEMS IN SRI LANKA

U.G. Amarawickrama[1*], T.D. Denagama[1]

[1]University of Vocational Technology -No 100, Kandawala Road, Rathmalana

**Correspondence E-mail:amarawickrama1990@gmail.com, TP: +94767172106*

Abstract: On-site sewerage treatment systems are the widely used system in Sri Lankan context to treat sewage, The expectation of the process of treating sewage is to ensure human health and safety. However, urbanization, converting natural environments to built environments, and changes in hydrological and meteorological conditions have been affecting failing sewerage treatment systems while creating health hazards and safety issues. Sewage is a hazardous waste containing pathogens that can pose significant threats to warm-body species like humans, and it creates diseases and impacts environmental pollution. Hence, the study entails determining why on- site sewerage treatment systems fail in the application stage within a short time period, with the objectives of investigating potential causes for failures and determining whether septic system malfunction occurred as a result of a difference between considered design conditions and actual conditions at the application stage. In finding out the applicable causes, a background analysis has been carried out by referring to literature and case studies for five cases where a recently implemented septic system failed. The provided systems for the considered cases have been checked against actual site conditions at the application stage, and the standards followed for proposing the same system. With the results of the study, it was found that, when providing the On-site sewerage treatment system, the actual site condition available had been neglected carelessly. Available soil characteristics, ground conditions, actual percolation rates, seepage paths, environmental factors, and physical factors affecting sewerage treatment should be taken into consideration and addressed before proposing an On-site treatment system. On-site sewerage treatment systems are one of the key components in any building. Its performance will enhance the quality of human life in the long run, but it is clearly identified that the value given for implementing a practical and applicable system is not at an acceptable level.

Key Words: Septic System; Soakage pit; Effluent; Percolation

ICSBE 2023-221

A REVIEW OF IMPACTS OF OCEAN ACIDIFICATION ON CORAL REEFS

P.M.M. Nilusha[1*], M. Danthurebandara [1], C. S. Kalpage [1]

[1]Chemical and Process Engineering Department, University of Peradeniya, Sri Lanka.

**Correspondence E-mail: mn.gsc97@gmail.com, TP: +94 713228267*

Abstract: Coral reefs are rich in marine biodiversity and essential for maintaining the ecosystem as they provide extensive ecosystems services such as creating breathing environment for marine lives and providing storm protection with regulating erosions. Human activities, both direct and indirect, are causing coral reefs to become endangered. Due to the climate change, reef diversity and coral growth are depleted, and it will create adverse effects to the existence of all the living beings. This review paper examines the impact of ocean acidification on coral reefs through the process of coral calcification. The main cause of ocean acidification is identified as the high uptake of carbon dioxide from the atmosphere by the ocean, which is primarily caused by the burning of fossil fuels. The paper compares various solutions for addressing ocean acidification and finds that mitigation strategies have high feasibility and potential. It is identified that there is currently a dearth of information regarding the combined effects of ocean warming and acidification on coral reefs, which is the actual situation.

Keywords: Ocean acidification; Coral calcification; Climate change; Solutions; Anthropogenic carbon dioxide emission

ICSBE 2023-239

HEALTH QUALITY ASSESSMENT OF THE BEERALLA STREAM IN ELLA WITH RESPECT TO THE SELECTED PHYSICO-CHEMICAL AND BIOLOGICAL FACTORS IN WATER: AN ASSESSMENT OF THE EFFECTS OF UNSUSTAINABLE TOURISM PRACTICES

R. M. A. Dilini[1*], J. Manatunge[2], G.G.N. Thushari[3], S.M. Gnanasingha[4]

[1]Department of Environmental Studies, Faculty of Technology, Sri Lanka Technological Campus, Padukka, Sri Lanka

[2]Department of Civil Engineering, Faculty of Engineering, University of Moratuwa, Moratuwa, Sri Lanka

[3]Department of Animal Science, Faculty of Animal Science and Export Agriculture, Uva Wellassa University, Badulla, Sri Lanka

[4] Department of Zoology and Environmental Management, Faculty of Science, University of Kelaniya, Sri Lanka

**Correspondence E-mail: asankadilini1@gmail.com, TP: +940711903009*

Abstract: Beeralla stream is a tributary of Kirindioya flowing through Ella, an enchanting town and well-known tourism destination. The stream is particularly vulnerable to pollution from tourism-related activities. The present study intends to assess the spatio-temporal water quality and levels of organic pollution in the surface water of the stream. After considering different land use patterns, parameters such as pH, Conductivity, Temperature, Total Suspended Solids (TSS), Turbidity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Nitrate and Total Phosphate (TP) were measured in surface water samples in selected locations from March to November 2021. Aquatic macroinvertebrates and dragonflies identified to the family level at the time of water sample collection. All measured surface water quality parameters were significantly different among sampling locations ($p<0.05$). The mean values for Nitrate, TP, BOD_5 and COD in mid segment of the stream were significantly higher than that of other segments ($p<0.05$).This area is influenced by uncontrolled wastewater discharges of riverine encroached hotels and restaurants. Nitrate, TP, TSS, BOD_5 and COD content were significantly higher in January and March than in other months ($p<0.05$). Collectively, TSS, turbidity, DO, phosphate, COD and BOD_5 levels in the stream are exceeded the Sri Lankan ambient water quality standards. A total of 15 species of macroinvertebrates were identified and the water quality of Beeralla stream acts as an organic pollution spot with poor water quality based on the values of Shannon Wiener Diversity Index (1.31-1.94) and Family Biotic Index (5.56 – 8.24). Stream subjected to this study enhances recreational value by encouraging tourism industry in Ella. The results of this study highlight the urgent need to adopt effective pollution management with the active involvement of all the stakeholders in Ella. This is the first study to be conducted in a freshwater ecosystem in Ella aimed at examining the detrimental consequences of tourism activities on water pollution.

Keywords: Macroinvertebrate; Freshwater Pollution; Wastewater; Water Quality

ICSBE 2023- 262

ULTRASONIC MODIFICATION OF ADSORBENTS FOR ENHANCEMENT OF THE PERFORMANCE IN DYE REMOVAL FROM AQUEOUS SOLUTION

L.K.K.N. Perera[1], K.H.M. Kuruwita[1], B.M.W.P.K. Amarasinghe[1*]

[1]Department of Chemical and Process Engineering, University of Moratuwa, Sri Lanka.

**Correspondence E-mail: padma@uom.lk, TP: +94716558759*

Abstract: The effect of the ultrasonic modification of the adsorbent towards adsorbent capacity for dye removal from aqueous solutions was tested. A cationic dye, Crystal Violet was chosen as the textile dye. The adsorbents for the experiment included commercially available activated carbon, Albizia sawdust, and Dried-areca nut husk (Puwak). For each adsorbent, two sets of batch adsorption experiments were carried out, one with and one without ultrasonic treatment, while keeping all the other parameters constant. The experimental results showed an increase in adsorption capacity due to sonication. Sonicated activated carbon, saw dust and areca nut husk showed 93%, 92% and 90% dye removal respectively. Activated carbon showed 33% increase in adsorption capacity compared to non-sonicated material which is the highest enhancement due to sonication, whereas saw dust and areca nut husk showed only 1% and 5.8% increase. Kinetic analysis showed that 86% of the dye removal from the sonicated activated carbon had taken place within the first 16 minutes of the experiment. Kinetic data was fit to the pseudo-second order model. The intra-particle diffusion model proved that film diffusion was significant in controlling the adsorption of dyes onto the adsorbent in addition to intra-particle diffusion. FTIR analysis showed that the existence of hydrogen bonds, C=C bonds, aromatic rings, aliphatic-iodo compounds, and other molecules contributed to the dye adsorption. SEM analysis showed that adsorption had happened into the resultant enlarged pores due to Ultrasonic vibration. The overall summary of the experiment through the results and analysis revealed that the vibration occurred during the ultrasonic treatment was the highly affected factor to enhancement of adsorption capacity of activated-carbon.

Keywords: Batch Adsorption; Adsorbents; Crystal Violet; Ultrasonic treatment; Kinetic analysis

WATER RESOURCES PLANNING AND POLLUTION CONTROL SESSION

ICSBE 2023-01

STUDY ON GARBAGE ACCUMULATION IN MAHAWELI RIVER, NEAR POLGOLLA RESERVOIR

T.D. Denagama [1*], D.E. Liyanage [1]

[1]University of Vocational Technology ,100, Kandawala Road, Ratmalana.

**Correspondence E-mail: tdenagama@yahoo.com , TP: +94714972340*

Abstract: In Polgolla Dam is one of the dams which was constructed across the Mahaweli River. It is located at Polgolla that very closer to the Kandy city area and the urbanization of this area is higher than the other dams in Mahaweli River. Due to this smaller reservoir capacity, the fluctuation of water inflow, diversion, and downstream discharges are highly varied. Polgolla Dam also has been constructed by focusing on flood control, diversion of water to irrigation and other requirements, and power generation. During rainy seasons, Polgolla Dam is mainly focused to control the flood inflow. Blocking the water intake tunnels which convert the water to power plants is a major problem and then have to stop the power generation until clean the intake structures. Sometimes that accumulated garbage is stuck inside the spillway gates and rollers when operating the gates to discharge the garbage downstream. The most environmentally harmful thing is, most of the garbage from these is discharged or released to the downstream side of the dam without any collection. The main aim of the study is to identify reasons and recommendations for the Garbage accumulation in the Mahaweli River, near Polgolla Reservoir. This research is mainly conducted as a survey-type research approach by conducting preliminary information gathering, sampling, data collection and analysis. Field visits are conducted to observe the effect of the garbage accumulation near Polgolla reservoir, and observations are noticed along the river to get some preliminary information about garbage disposal in the river. As per the analysis attitude and behaviors of the people, lack of rules and regulations, poor coordination, and the link between relevant authorities are the main reason behind this issue. Garbage accumulation can be controlled in both short-term and long-term strategies such as the introduction of suitable garbage traps and booms (e.g Bamboo log boom), attitude change of the river users and nearby communities, stringent existing rules and regulations on the garbage dump, and establishment of proper coordination among authorities.

Keywords: Garbage; Mahaweli River; Polgolla Dam; Reservoir

ICSBE 2023-30

WATER MANAGEMENT OF ROTTAI TANK SCHEME IN POTTUVIL IRRIGATION DIVISION

YKMRC Yapapatune [1*], DA Ekanayake [1], PDS Senevirathne [1],Eng.S.Tharshika [1]

[1]Department of civil engineering, South Eastern university of Sri Lanka,Oluvil,Sri Lanka.

**Correspondence E-mail: rashchaya@gmail.com, TP: +94703624509*

Abstract: Water management is a crucial factor in water-deficient regions, especially in Sri Lanka's Eastern province where water scarcity is a major concern. Effective management of water resources is particularly important in that region because irrigation plays major role of their livelihood. This study employs the CROPWAT; and Water Evaluation and Planning (WEAP;) software to assess the water management of the Rottai tank in the Pottuvil irrigation division of the Ampara district. This research examines essential data such as rainfall, evapotranspiration, soil properties, and crop information and provides an evaluation of various water use models for the irrigation water requirement scenarios in the region and finally suggest the most effective water management model for optimizing irrigation water demands. Modeling methods were employed to collect the data. Evapotranspiration data for the Rottai tank was collected using the CLIMWAT; software. Crop water requirements were determined using the CROPWAT tool. WEAP model was developed by integrating the crop water requirements, monthly inflows, and reservoir capacities of the Rottai tank. In conclusion, this study highlights the importance of effective water management; in water-scarce regions such as Sri Lanka's Eastern province by using advanced modeling tools to optimize water use efficiency. The findings of this study can be used to implement effective water management strategies that can be give better irrigation systems of the region.

Keywords: CROPWAT; WEAP; CLIMWAT; Water management

ICSBE 2023-40

IMPROVED OPERATION OF MINIPE LEFT BANK CANAL IRRIGATION SYSTEM

S. Ranwala[1]*, U.H.M.S. Silva[1], K.D.W. Nandalal[1]

[1]Faculty of Engineering, University of Peradeniya, Sri Lanka

** Correspondence E-mail: e16316@pdn.ac.lk, TP: +94776060914*

Abstract: The Minipe left bank canal has a head-tail water imbalance as a result of inadequate water availability, ineffective and unfair agricultural water distribution. To reduce the difference, Minipe anicut is raised by 3.5 m. Though ample water may be released by this step, due to poor management, irrigation water would not be evenly distributed along the canal. Therefore, developing an improved water distribution pattern in the canal is vital. The study focuses on establishing an operational strategy for the Minipe left bank canal irrigation system that would ensure the entire command area receives enough water during both the Yala and Maha seasons. This was accomplished through the use of simulation models. The Minipe left bank canal's operational pattern was modeled using inflows and irrigation demands. The catchment inflows to the contour canal were determined based on rainfall-runoff models developed using HEC-HMS software. The CROPWAT program was used to estimate crop water requirements. Finally, the WEAP program was used to simulate irrigation system operation based on the water balance principle. By combining new cropping patterns, shifting sowing dates, and Minipe anicut discharges, six scenarios (including the Business-As-Usual Scenario) were evaluated. The emphasis was placed on lowering unmet demands in the Yala season because were significantly higher than demands in the Maha season. A cropping pattern of 70% paddy and 30% other field crops, a 2 week delay in sowing date, and raising the Minipe anicut discharge by 15% in the Yala seasons were found to reduce unmet demands. According to the analysis, making the aforementioned adjustments will enhance the Minipe left bank canal operational pattern and reduce unmet demand by 75%.

Keywords: Minipe; HEC-HMS; CROPWAT; WEAP; Scenario; Operational Pattern

ICSBE 2023-55

ASSESSING THE STRUCTURAL STRENGTH OF FABRICATED BURNT CLAY ECO-BRICKS WITH RICE HUSK ASH AND ALUM SLUDGE

N. H. M. S. Bandara[1], S. Himanujahn[2], W. A. K. S. Fonseka [1,2], B. C. L. Athapattu[1,2*]

[1]Department of Civil Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka, Nugegoda, Sri Lanka.

[2]Centre for Environmental Studies and Sustainable Development, Thre Open University of Sri Lanka, Sri Lanka.

[*]Correspondence E-mail: bcliy@ou.ac.lk, TP: +94777577321

Abstract: According to existing legislation, water treatment sludge is classified under industrial waste. The National Water Supply and Drainage Board of Sri Lanka spends a considerable amount to displace dried sludge into the nearest land. It generates a universal issue that disturbs the natural ecosystem and human health. Therefore, attention has to be paid to identifying disposal routes, sustainable practices and potential applications of water treatment sludge. Since clay is a limited natural resource and water treatment sludge is extremely close to clay in chemical com- position, it could be a potential substitute for clay to the ecological and monetary challenges in the clay brick industry. As an agricultural waste, rice husk contains high silica and could be incorporated into cementing in brick manufacturing providing an environmentally sound approach to reuse rice husk ash. Three different series of sludge and rice husk ash to clay proportions were studied, which exclusively involved the addition of sludge with ratios 20%, 25% and 50% of the total weight of the brick composite. Each brick series was fired at 700℃, 800℃, 900℃ and 1000℃. The physical and mechanical properties of the produced bricks were determined and evaluated according to Sri SLS 39:1978 and compared with control bricks. Compressive strength was increased with the increment of bricks incinerated temperature and clay content. Shrinkage was decreased and water absorption was increased with an increment of sludge and rice husk ash content. The addition of 20% sludge and 10% rice husk ash to 70% of clay that incinerated at 1000℃ met the minimum requirement of 2.8 N/mm^2 compressive strength and 28% water ab- sorption values of Grade II building bricks. The invented lightweight eco-bricks are extremely suitable for high thermal insulating and sound absorbing walls, non-load bearing or partition walls and flooring with comparing its compressive strength.

Keywords: Brick; Clay; Rice husk ash; Sludge disposal; Water treatment sludge

ICSBE 2023-78

UNRAVELING CLIMATOLOGICAL TRENDS: 50-YEAR ANALYSIS OF LONG-TERM PARAMETERS IN KIGALI, RWANDA

N.R. Josiah[1*], D.P.C. Laknath [2]

[1]Department of Civil Engineering, Osaka University, Japan.

[2]Lanka Hydraulic Institute Ltd., Moratuwa, Sri Lanka

**Correspondence E-mail: josiah.jofdh@slmail.me TP: +81668797614*

Abstract: Analysing long-term climatological trends in Africa is crucial for informed decision-making, climate change adaptation, disaster risk reduction, policy formulation, and scientific advancements concerning the sustainable development of water resources facilities. This study focused on Kigali, the capital city of Rwanda, as a representative country to comprehend long-term climate variations. Despite being in the tropical belt, Kigali experiences a temperate climate due to its high elevation. This research aimed to cover the 1971-2021 (i.e. 50 years) period with extensive meteorological variables such as rainfall, temperature, relative humidity, evaporation, sunshine duration, wind, and atmospheric pressure to identify long-term variations in climatological parameters in Kigali, using data at the Kigali Airport weather station. In this study, annual anomalies and non-parametric Mann-Kendall test were utilised to determine the trends of each parameter. The findings revealed an increasing trend in temperature over the past 50 years at Kigali-Aero station. Conversely, rainfall and relative humidity decreased during the same period. The results suggest an expected increase in evaporation due to rising temperatures and decreasing humidity, which was confirmed by a positive trend in evaporation. Additionally, wind speed and atmospheric pressure showed a positive trend over the past five decades.

Keywords: Climatological data; Annual anomalies; Mann-Kendall test; Trend analysis

ICSBE 2023-95

ASSESSMENT OF THE BEHAVIOUR OF FLOW PATTERNS WITH THE PRESENCE OF R PUMP HOUSE, RAISING OF FLOOD BUNDS USING 2D HYDRAULIC NUMERICAL MODELING

S.M.Hewavidana[1], K. Subasinghe[1*]

[1]Lanka Hydraulic Institute Ltd, 77 John Rodrigo Mawatha, Moratuwa

[*]Correspondence E-mail: suba.hewavidana@lhi.lk, +94774706040

Abstract: The study area is covered the Madiwela canal from 150m upstream of existing flood bund to the canal outlet to Kelani River. MIKE 21 flow model for the considered canal stretch was setup with obtaining boundary condition related to design storms. Model simulations were carried out for the existing and proposed conditions with pump house and outlet canals. Magnitude of flow currents within the selected canal stretch and flood levels in the vicinity of pump house were estimated. Based on the model results under worst scenarios up to 50 year return period, it is observed that there is no interchange of flow by overflowing the flood bund either from Kelani River Side to Canal side or from canal to river side. Hence, the raised level of +7 m MSL of the flood bund is adequate. The right bank in front of pump house seems to have marginally high velocities and becomes vulnerable for erosion.

Keywords: MIKE 21 2D flow model; Flood; Pump house; Flood bund

ICSBE 2023-108

SCALE EFFECT ON RAINFALL-RUNOFF MODELING IN UPPER KELANI RIVER BASIN, SRI LANKA

M.K.D.K.C. Madapatha[1*], W.A.I. Madhawa[1], M.M.G.T. De Silva[2]

[1] Department of Civil Engineering, University of Peradeniya.

[2] Senior Lecturer, Department of Civil Engineering, University of Peradeniya

**Correspondence E-mail: e16211@pdn.ac.lk, TP: +94770444003*

Abstract: Rainfall-runoff modeling is one of the key concepts in hydrological engineering. The necessity of rainfall-runoff modeling is evident because the conversion of rainfall into the runoff is not a simple, linear process. This research aimed to use HEC-HMS to evaluate the impact of scale effect on rain-fall-runoff modeling in the upper Kelani River basin. Three basin models were used; (1) the whole basin as a single unit, (2) divided the basin into 3 sub-basins, and (3) divided the basin into 5 sub-basins. These models were done using ArcGIS. The runoff was simulated in HEC-HMS for both calibration (1998-2015) and validation (1990-1997). The simulated discharge at the Hanwella outlet was compared with the observed discharge and the goodness of fitting was estimated with the use of the Nash–Sutcliffe Coefficient, Root Mean Squared Error to Standard Deviation (RMSE-SD) ratio and Percentage Bias. The results showed an improvement in the Nash-Sutcliffe coefficient from a single basin to five sub-basins, with values of 0.74, 0.75, and 0.79. However, the improvement was not significant. Further, the analysis of bias values indicated that the single basin provides the best outcome compared to the other two simulations. Therefore, the authors suggest that dividing the basin into subbasins is not really worth it and considering the whole basin as a single unit provides good results, with a more convenient and less time-consuming process. Finally, the study concluded that the scale effect is not a crucial factor to be considered for accurate runoff modeling in the upper Kelani River basin.

Keywords: Rainfall-Runoff Modeling; Scale Effect; HEC-HMS; Upper Kelani River Basin; Nash-Sutcliffe coefficient

ICSBE 2023-111

WATER QUALITY MODELLING AND IMPROVEMENT OF WATER SAFETY OF RAMBAKAN OYA RESERVOIR CATCHMENT IN MAHA OYA IRRIGATION DIVISION

Y.M Saifudeen[1], A.J.F Mazeera[1*], A.C.A Suja[1]

[1] Department of Civil Engineering, Faculty of Engineering, South Eastern University of Sri Lanka, Oluvil.

**Correspondence E-mail: mazeerajabbar@gmail.com, TP: +94772659273*

Abstract: The Rambakan Oya reservoir is the primary water source for the Maha Oya water supply scheme and provides irrigation for paddy cultivation. In early 2020, this reservoir was highly affected by algal blooming throughout its catchment area. Therefore, this comprehensive study was conducted to identify the sources of pollutants and propose water safety plans for the Rambakan Oya reservoir catchment. Water samples were collected from twenty different locations on the surface of the reservoir, by taking into account the outlets of streams to the reservoir. The results indicated that Nitrite, Chemical Oxygen Demand (COD) and total coliform are the most potential pollutants beyond the safe level for drinking water. To analyze the potential pollutant loading based on various land use patterns, the Storm Water Management Model (SWMM) was employed. Moreover, using a hazard matrix analysis, all potential hazards, both visible and hidden that could contaminate the water in the reservoir were thoroughly investigated in accordance with module number three of Water Safety Plans (WSP). The findings show that the potential pollutant loading at critical outlets increased with deforestation, while the impact of development activities on pollutant load was relatively insignificant. On the other hand, forest extent of 30% only affected a 5% increase in pollutant loading. These findings highlight that the primary cause of the undesirable impact on the Rambakan Oya reservoir is the runoff from cattle farms, carrying water contaminated with faecal matter and urine, rather than land development activities. Moreover, surface runoff generated from agricultural lands and faecal pollution due to domestic effluents is in the next higher-order level of risk. Therefore, risk mitigation measures alone cannot ensure the safety of the reservoir, the contribution and support of stakeholders are also crucial to enhancing the safety of the Rambakan Oya reservoir.

Keywords: Algal Blooming; Land Use; Pollutant Loading; Stakeholders

ICSBE 2023-118

DYNAMIC BEHAVIOR OF SALINITY INTRUSION IN KELANI RIVER, SRI LANKA

V.D. Athuraliya[1*], N.G.P.B. Neluwala[1] , K.P.P.Pathirana[1]

[1]Faculty of Engineering, University of Peradeniya, Peradeniya, Sri Lanka

**Correspondence E-mail: virangada@gmail.com, TP: +94762042957*

Abstract: Within the context of climate change, the intrusion of salinity into rivers stands as a paramount concern for the management of coastal water resources. This problem is exacerbated by various contributing factors, including rising temperatures, fluctuations in river discharge during dry periods, sea-level elevation stemming from climate change, and the gradual lowering of riverbeds. This paper introduces a sophisticated multi-dimensional hydrodynamic and transport model tailored for the lower Kelani River basin, employing the Delft3D-FLOW and D-WAQ models. This integrated model takes into account critical parameters such as streamflow, tidal dynamics, temperature, and salinity conductivity as essential boundary conditions. Calibration involves fine- tuning parameters such as bottom roughness, viscosity, and diffusivity, while validation is executed using actual measurements of water levels and conductivity within the river. The primary objective of this study is to investigate the behaviour of saline intrusions within the Kelani River and their responses to sea-level elevations attributed to global climate shifts. The investigation is particularly focused on two key timeframes: the middle of the 21st century (2050) and its conclusion (2090), in alignment with projections outlined in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). The model's forecasts indicate that, in relation to 2020 conditions, a saline front of 1 part per thousand (ppt) is anticipated to advance further inland by approximately 0.5 km, 3.5 km, 8.5 km, and 11 km, corresponding to sea-level increases of 21 cm, 32 cm, 37 cm, and 48 cm, respectively.

Keywords: Kelani River; Salinity Intrusion; Delft 3D; IPCC

ICSBE 2023-121

ORGANIC MEMBRANE FILTERS FOR TEXTILE WASTEWATER TREATMENT: A REVIEW

R.P.D.D. Senarathne[1*], C.S. Kalpage[1]

[1]Department of Chemical and Process Engineering, Faculty of Engineering, University of Peradeniya, Peradeniya, 20400, Central Province, Sri Lanka.

**Correspondence E-mail: dinishi.senarathne@gmail.lk, TP: +94771955892*

Abstract: Textile wastewater has been identified as a potential source of environmental pollution mainly due to the presence of synthetic dyes that are resistant to natural degradation. Membrane technology has recently emerged as a promising solution for treating textile wastewater. Membrane filters are fabricated with numerous types of materials and methods to give specific properties. Organic membranes, as opposed to inorganic membranes, are regarded as the most favourable membranes due to their lower cost, flexibility, and ease of pore formation mechanism. The main purpose of this study is to investigate efficient polymeric membranes with low environmental impact. Because of their hydrophobic nature, conventional pure polymeric membranes are prone to fouling and therefore, alterations are needed to overcome their limitations. This review paper discusses membranes that have been modified to improve their performance using techniques such as blending, surface grafting, coating, and interfacial polymerization. Notably, blending Polyvinyl Alcohol with natural derivatives enhances the removal efficiency of cationic dyes to over 90%. Polysulfone blended membranes exhibit moderate removal efficiency for anionic dyes within the 300-500 g/mol molecular weight range. While surface grafting enhances membrane performance, it poses durability challenges and difficulties in scaling up for industrial use. Interfacial polymerized polyester membranes and cellulose acetate-coated membranes exhibit considerable potential for industrial applications, effectively removing dyes within the 300-1500 g/mol molecular weight range.

Keywords: Membrane filter synthesis; Polymeric membranes; Surface modification methods; Textile dye removal

ICSBE 2023-123

DETECTION OF MICROPLASTICS FROM DOMESTIC LAUNDERING USING ATTENUATED TOTAL REFLECTANCE – FOURIER TRANSFORM INFRARED (ATR-FTIR) SPECTROSCOPY

Vigneswaran Nitharshan[1], Sajani Kolambage[1], Tharanja Gobalakrishnan[1], Aravinda Nirella [2],Nimantha Jayanaka[2], Pradeep Gajanayake [1,*], Rohan S. Dassanayake [1,*]

[1]Department of Biosystems Technology, Faculty of Technology, University of Sri Jayewardenepura, Pitipana, Homagama, 10200, Srilanka

[2]Techno Instruments Private Limited, Kalubowila, Dehiwala 10350, Sri Lanka.

** Correspondence E-mail: rdassanayake@sjp.ac.lk, pradeepgajanayake@sjp.ac.lk*

Tel: +94703268030, +94771522444

Abstract: Microplastics (MPs) are anthropogenic pollutants present predominately in rivers, lakes, oceans, remote islands, and polar regions. MPs are an emerging threat to the environment and human and animal health with potential adverse effects. Among many MP emitters, textile industries are considered one of the major contributors to MP pollution in the aquatic environment. Synthetic textile fibers, including polyester, nylon, and acrylic, release a considerable number of MPs during washing and wearing. However, MPs below 100 µm are extremely difficult to detect and identify using microscopic techniques. Therefore, the current study aimed to investigate the detection of MPs released from synthetic fabrics during domestic laundering by attenuated total reflectance- Fourier transform infrared (ATR-FTIR) spectroscopy. A Plankton net was used to separate and collect MPs from fabric wastewater. ATR-FTIR analysis was conducted on the dried MPs collected from two synthetic fabrics, polyester and nylon. Our results show that polyester fabrics have approximately 1.8 higher MP emissions than nylon during mechanical washings, causing the highest environmental impact. The amount of MPs released during laundry washing of 1 kg of load is 1.1 and 0.62 g for polyester and nylon fabrics. Moreover, the ATR-FTIR technique exhibits the potential to detect MP emissions from different synthetic fabrics.

Keywords: Polyester; Nylon; Microplastics; ATR-FTIR; Domestic Laundering; Environmental Pollution

ICSBE 2023-126

ACCURACY OF CURVE NUMBER METHOD IN ESTIMATING RAINFALL-RUNOFF RELATIONSHIP FOR SUGARCANE LAND USE UNDER TROPICAL CLIMATE IN SRI LANKA: A COMPARATIVE STUDY OF MEASURED AND COMPUTED DATA

L. M. J. R. Wijayawardhana[1*], K. D. N. Weerasinghe[2], and C. M. Navaratne[3]

[1]Sugarcane Research Institute, Udawalawe, Sri Lanka

[2]Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka and Faculty of Technology, Horizon Campus, Millenium Drive, Malambe, Sri Lanka

[3]Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka

**Correspondence E-mail: lmjrw@yahoo.com, TP: +94472233233*

Abstract: A field experiment was conducted to test the applicability of the Soil Conservation Service Curve Number (SCS-CN) runoff estimation method, aiming to suggest an appropriate curve number for the sugarcane land use system in Sri Lanka. Runoff plots with 12 m^2 having uniform field geometry were established in 11 different farmer fields. Calibrated plastic buckets were placed at the lowest end of the run-off plot to measure runoff. Rainfall was measured using 11 manual rain gauges installed in each runoff plot. Soil infiltration rate was measured using double-ring infiltrometers placed at the central location of each plot. The study was continued for two consecutive crop cycles: 2018-2019 for the virgin crop and 2019-2020 for the ratoon 1 crop. The Willmott index of agreement test was employed to compare the modelled runoff with the measured runoff. The results indicated that the most suitable curve number for the virgin crop of sugarcane in Sri Lanka was 62 under antecedent moisture class II. The selected curve number 62 ranged from 42 to 80 depending on the antecedent moisture condition in class I and class III, respectively. Furthermore, it was observed that available crop residues after harvesting of sugarcane led to a reduction in surface runoff, resulting a decrease of the curve number approximately 3 units (CN 59). This finding highlights the significance of keeping crop residues without burning, to increase rainfall infiltration and enhances the availability of water for crop production.

Keywords: Curve Number; Run-Off; Soil Conservation Service; Sugarcane

ICSBE 2023-128

A CASE STUDY ON INVESTIGATING THE QUALITY ASSURANCE AND CONTROLLING PRACTICES IN THE WATER SUPPLY PROJECTS OF THE NATIONAL WATER SUPPLY AND DRAINAGE BOARD SRI LANKA (NWSDB-SL)

Jathursan S[*], Gobidan N.N [2]

[1]*Wayamba University of Sri Lanka, Lional Jayathilaka Mawatha, Kanadhulla , Kuliyapitiya*

[2] *Urban Development Authority, Sethsiripaya , Battaramulla, Sri Lanka*

**Correspondence E-mail: singamjathu1@gmail.com, TP: +94 778695221*

Abstract: The National Water Supply and Drainage Board in Sri Lanka (NWSDB-SL) is a government organization responsible for managing water supply and drainage services in the country. It plays a crucial role in ensuring the provision of safe and reliable water to the population and managing wastewater and drainage systems. This case study explores the quality assurance and controlling practices in the water supply projects of the National Water Supply and Drainage Board in Sri Lanka (NWSDB-SL). The study aims to identify the root causes of poor quality assurance and controlling practices and proposes mitigation methods to improve them. The research objectives include identifying poor practices related to quality assurance and controlling, identifying causes that influence current practices, proposing mitigation methods, and developing a new template to enhance quality assurance and controlling practices in NWSDB-SL's work operations. The study uses mixed-methods approach, including surveys, interviews, and document analysis, to gather data. The findings reveal several poor practices related to quality assurance and controlling in NWSDB-SL's water supply projects, including inadequate training, ineffective management, and a lack of standard operating procedures. The causes of these poor practices include inadequate resources, insufficient policies and guidelines, and a lack of accountability. The study proposes several mitigation methods to overcome these challenges, including training and capacity building, developing standard operating procedures, and implementing quality control mechanisms. Finally, the study presents a new template for enhancing quality assurance and controlling practices in NWSDB-SL's work operations. The proposed template is expected to improve the quality of water supply projects and enhance customer satisfaction

Keywords: Quality Assurance practices; Quality Controlling practices; water supply projects; National Water Supply and Drainage Board, Sri Lanka. (NWSDB-SL)

ICSBE 2023-203

ENHANCING FISH HEALTH, WATER QUALITY, AND ENVIRONMENTAL RESPONSIBILITY WITH AN INTEGRATED AQUAPONIC APPROACH TO REVERSE OSMOSIS (RO) REJECT WATER MANAGEMENT

W.P.Madhushani Perera[1*], M.T.U.D. Mallikarathne[2], G.A.H.K.M. Gamlath[1], A.M.H.M. Abeysinghe[2]

[1] Department of Engineering Technology, Faculty of Technological Studies, Uva Wellassa University

[2]Department of Instrumentation and Automation, Faculty of Technology, University of Colombo

**Correspondence E-mail: beta16050@std.uwu.ac.lk, TP: +94725042806*

Abstract: Due to its low mineral content, high temperatures, and chemical residues, the production of Reverse Osmosis (RO) reject water in water treatment procedures creates difficulties in safe disposal. To release RO reject water into the environment responsibly and to protect aquatic life's health and vitality, this project will develop a novel system. The main goals are to use swimming fish as water quality indicators in aquatic environments inside a multi-chambered cement tank with an aquaponics system. The implementation of temperature reduction techniques is necessary due to the high water temperatures of RO reject water. The water is circulated through several chambers and surface agitation with blowers and air pumps helps to achieve the appropriate temperature range of 24–30°C. This cooling procedure improves the conditions for the fish and aids in effective oxygenation. Crushed corals are added to the water to remedy the low mineral content problem. The growth of fish bone and tissue depends on the total dissolved solids (TDS), general hardness, and carbonate hardness, all of which are improved by this addition. These minerals are incorporated into the experiment's design to protect the fish's health. The paper also discusses how activated carbon, appropriately positioned before the crushed coral, can be used to remove chemical residues like citric acid and NaOH. This process makes sure that any dangerous compounds are removed without harming the helpful minerals the corals give. This study's incorporation of an aquaponics system inside the tank constitutes its innovative component. With the help of this layout, fish and hydroponically grown plants can coexist in harmony. The overflow water supplies the plants with nutrient-rich water that has been supplemented with minerals from the crushed corals. The plants then aid in the filtration of the water by absorbing extra nutrients and organic substances.

Keywords: Aquaponics system; RO reject water; Fish health; Water quality; Environmental responsibility; Temperature control

ICSBE 2023-224

OPTIMIZING PHYSICS PARAMETERS FOR HEAVY RAINFALL FORECASTING IN THE KELANI RIVER BASIN USING THE WRF MODEL

P.L.L.N. PERERA[1*], N.G.P.B. NELUWALA [1], J.J.WIJETUNGE[1]

[1]University of Peradeniya, Peradeniya, Sri Lanka.

**Correspondence E-mail:lakmininadeesha95@gmail.com, TP: +94703263736*

Abstract: It is imperative to increase the precision of flood forecasts for the long-term sustainability of developing economies, particularly for reducing losses and damages in metropolitan regions, which are typically the driving forces behind the economy. Moreover, with climate change, floods are becoming more frequent, underscoring the need for accurate flood forecasting system to reduce property and life losses. A precise prediction of floods requires accurate estimations of extreme rainfall occurrences with a longer lead time. To produce fine-scale rainfall predictions, regional weather forecasting models with high resolution, such as the Weather Research and Forecasting (WRF) model are frequently utilized to provide rainfall estimations at fine grid spacing. These events depend on multi-scale interactions and model parameters such as, grid spacing, physical parameterization and initialization. This study sought to discover the most effective set of physics parameters for forecasting heavy rainfall events in Kelani River basin by evaluating the predictability of the WRF model with several model physics alternatives. WRF model consisted of three domains with resolution of 27 km, 9 km and 3 km was used in this work by taking into account two representative extreme rainfall events that occurred during the South West monsoon season in 2020 and 2021, over the Kelani river basin. Each event was simulated with ensembles involving four different microphysics and two cumulus parameterizations. The simulated rainfalls were evaluated against the observations from 15 rainfall gauging stations in the river basin. The results suggest that the WSM3 and WSM6 microphysics schemes with the Betts–Miller–Janjic cumulus scheme can be chosen as the optimum parameterization schemes to be used in this region.

Keywords: Flood forecasting; Kelani River Basin; WRF model; Physics parameters optimization

ICSBE 2023-268

AI-BASED MACHINE LEARNING ALGORITHMS FOR WATER QUALITY ANALYSIS: A REVIEW

R.M.L.S Rajapaksha[1*], R.P.W.N Karunasiri[1], T.A.N.T Perera[2], Kosala Sirisena[1]

[1]Department of Environmental Technology, Faculty of Technology, University of Colombo, Sri Lanka

[2]Department of Export Agriculture, Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka

**Correspondence E-mail:laksameera456@gmail.com , TP: +94773132103*

Abstract: Water quality assessment is a basic concept of environmental management bearing profound implications for human health and well-being. Artificial Intelligence (AI) based machine learning (ML) algorithms have steered in a paradigm shift by enabling precise, efficient, and real-time analysis of water quality traits. However, in-depth analysis of the ever-evolving AI-driven ML applications in the domain of water quality analysis is absence in the tropical regions. Therefore, this review was conducted (a) to explore ML algorithms in groundwater, surface water, and drinking water assessments, and (b) to investigate potential future applications of ML algorithms to water quality studies. From 2012 to 2022, 30 indexed journal articles were reviewed in terms of the characteristics and capacities of creating methods, taking into account data of input-output, etc. This review is confined to English language scholarly peer-reviewed journal papers, and books in Science Direct. Key terms driving the exploration include Artificial Intelligence, Machine Learning and Water Quality. ML algorithms have advanced water quality assessment across diverse aquatic contexts. They enable the analysis of extensive datasets, providing real-time insights and accurate predictions for improved water quality management. ML models in surface water quality evaluation use data from multiple sources, such as remote sensing and in-situ sensors, to monitor parameters such as turbidity and dissolved oxygen. They support in early pollution identification and management measures. These algorithms analyze data from monitoring wells to ensure the safety of drinking water sources when monitoring groundwater quality. By assessing water quality data and operational parameters, ML optimizes drinking water treatment operations. It anticipates and adjusts characteristics such as temperature and pH in aquaculture management to optimize operations. Future applications include early warning systems for pollution incidents and assessing the impact of climate change. The evolution of ML promises more informed decision-making and improved water quality management across aquatic environments. This review, concluded a comprehensive synthesis of perceptions drawn from diverse research endeavours, not only enhances the current state of AI-based water quality analysis but also delineates the path for future scientific exploration, thereby thrusting water quality management and ecological sustainability to new heights.

Keywords: Artificial Intelligence; Groundwater; Machine Learning; Surface Water; Water Quality

ICSBE 2023-344

EFFECT OF IRRIGATION RESERVOIRS ON STREAMFLOW SIMULATION IN DRY ZONE, SRI LANKA

Buddhi Suraweera[1*], Kasun De Silva [1]

[1]Department of Civil Engineering, University of Moratuwa, Moratuwa, Sri Lanka.

**Correspondence E-mail: prasadsb.22@uom.lk, TP: +94773266377*

Abstract: Advances in technology and its applications to hydrology and water resources engineering have created different approaches in modelling the hydrological response to climate change. However, hydrological modelling of a river basin where a major component of rainwater is utilized for irrigation purposes through rainwater storage reservoirs and interconnected irrigation canal systems remains complex. This study attempted to simulate the hydrological processes of the Malwathu Oya basin comprised of reservoir operations and inter-basin diversions using the HEC-HMS software package developed by the US Army Corps of Engineers. Irrigation water requirement of major irrigation schemes in the Malwathu Oya basin during the Yala and Maha cultivation seasons were estimated using the CROPWAT model and estimates were incorporated in hydrological modelling. Rainfall-runoff simulations were conducted for two scenarios (with and without reservoir operations) to analyze the impact of major reservoirs on river runoff. Average seasonal streamflow simulations at the Kappachchi river gauging station for with and without major reservoirs during the Yala season were 99.86 million m^3 and 189.63 million m^3 and during the Maha season estimates were 359.09 million m^3 and 686.88 million m^3. Runoff coefficient estimates for two scenarios imply the importance of incorporating reservoir operations in comprehending the hydrological processes of a reservoir-rich river basin.

Keywords: HEC-HMS; Malwathu Oya; Runoff coefficient; Irrigation reservoirs

ICSBE 2023-355

MODELLING STORM WATER MANAGEMENT SYSTEMS IN RESPONSE TO DIFFERENT RAINFALL AND LAND USE PATTERNS

Pramudika W.O.H. [*1], Ubhayaratna K.M.M. [1], Gunawardana W.C.T.K. [1]

[1]Faculty of Engineering, University of Peradeniya

**Correspondence E-mail:e16293@eng.pdn.ac.lk, TP: +94717588172*

Abstract: Stormwater flow in urban areas has increased due to rapid urbanization and changes in land use. In Sri Lanka, local government entities often face numerous physical barriers from the community despite offering innovative, sustainable stormwater management solutions. Due to a lack of required standards and technological advancements, alternative stormwater management practices have not received enough attention in local government development plans. Best Management Practices (BMPs) are emerging stormwater management alternatives to the traditional drainage system. This study evaluates and optimizes applications of seven scenarios of individual and different combinations of BMPs to minimize stormwater quantity issues in urban catchments. Various individual Best Management Practices (BMPs) are utilized, including Bio Retention Ponds, Detention Ponds, and Rain Barrels, either separately or in combination with each other. Stormwater infrastructure designers and operators rely heavily on the Storm Water Management Model (SWMM) developed by the United States Environmental Protection Agency to simulate stormwater and wastewater infrastructure performance. The main objective of this study is to identify suitable stormwater management alternatives using Best Management Practices (BMPs) to reduce water quantity issues in urban areas. The study demonstrates the effectiveness of BMPs in reducing total runoff volume on the types and combinations of BMPs used. Seven distinct scenarios were examined in a study to determine the effectiveness of different BMP options in reducing the risk of flooding in an urban environment. Peak runoff rate and total flood volume reduction rate at junction flooding were the performance indicators used in the study to gauge how effective each scenario was. According to the results, the sixth scenario which combined retention ponds with rain barrels was the most successful in lowering the risk of both kinds of flooding.

Keywords: Storm water model; Best Management Practices (BMPs); Urbanization; Scenarios; Urban runoff; Simulation

ICSBE 2023-349

BIODEGRADABILITY INDEX (BDI) AS AN INDICATOR FOR EFFLUENTS QUALITY MEASUREMENT; A CASE STUDY BASED ON DIFFERENT INDUSTRY SECTORS IN MATARA DISTRICT, SRI LANKA

G.R. Diwyanjalee[1*], B.K.A. Bellanthudawa[2], D.K.N.S. De Silva[1] ,A.R. Gunawardana[4]

[1]Southern Provincial Office, Central Environmental Authority, Galle 80630, Sri Lanka

[2]Department of Agricultural Engineering and Environmental Technology, Faculty of Agriculture, University Of Ruhuna, Matara, 81000, Sri Lanka

[4]Research and Development, Central Environmental Authority, Sri Jayawardenepura Kotte 10120, Sri Lanka

**Correspondence E-mail: rashmitha.diwya@gmail.com, TP: +94770567944*

Abstract: Biological oxygen demand (BOD) and chemical oxygen demand (COD) are crucial indicators for estimating aquatic pollution levels, as unrestricted discharge poses challenges for global water systems. Therefore, the present study aimed; (1) to investigate the Biodegradability Index (BDI) of effluents and assess the relationship between BOD and COD to predict wastewater characteristics compared them to Nilwala River as a reference water body and (2) to understand the relationship of BDI with other physicochemical parameters such as pH, temperature, electrical conductivity (EC) and total suspended solid (TSS). Water samples were regularly collected from January 2019 to December 2022 at seven vehicle service stations and two hotels in Matara district, Sri Lanka. The Standard APHA 23rd edition methods were used to analyze water quality parameters. Experimental results were statistically analyzed by One-Way ANOVA test and Mann-Kendall trend analysis using Minitab-17 and multiple linear regressions using IBM SPSS. BDI showed a statistically significant spatial variation among industry sites but did not show a significant difference with temporal variation. The BOD: COD ratio showed an increasing trend over time. However, this rising tendency is exceptionally modest. The low R^2 value indicates a weak linear relationship between time and the BOD: COD ratio. This implies that factors other than time are likely playing a significant role in determining the BOD: COD ratio. The relationship of BDI with the temperature, alkalinity and TSS was significant by explaining 1.1%, 6% and 6.3% of the variance in the outcome variables respectively. Therefore, it is concluded that even though the BOD: COD ratio is a key proxy in determining biological and chemical decompositions of aquatic systems, the present study suggests that it should be by other indicators of the degradation of organic matter in wastewater in assessing the industrial effluent quality.

Keywords: Biodegradability Index (BDI); BOD: COD ratio; Effluent quality; Mann-Kendall trend analysis; Unregulated effluent discharge

CAS SPECIAL SESSION : ADVANCEMENTS IN ECO-ENVIRONMENTAL SCIENCES AND WATER TREATMENT: A MULTIDISCIPLINARY APPROACH (JRDC SESSION)

ICSBE 2023-104

IMPORTANCE OF STUDY ON BIOFILM CHARACTERIZATION WITHIN DRINKING WATER DISTRIBUTION NETWORKS

E.G.W. Gunawardana[1*], D.R. Gunathilake[1], C. Ratnayake[1], K.R.A.D.U. Jeewarathne[1], M. Makehelwela[1], S.K. Weragoda[1], C.D. Gamage[2], R. Weerasooriya[3]

[1]China-Sri Lanka Joint Research and Demonstration Centre (JRDC) for Water Technology, E.O.E Pereira Mawatha, Peradeniya, Sri Lanka

[2]Department of Microbiology, Faculty of Medicine, University of Peradeniya, Peradeniya, Sri Lanka

[3]National Institute of Fundamental Studies, Hantana Road, Kandy, Sri Lanka

**Correspondence E-mail: wasanagun@gmail.com, TP: +94 71 6991843*

Abstract: Biofilms are normally present in pipe walls, storage tanks, and sediments of drinking water distribution networks (DWDNs). Despite drinking water treatment plants producing high-quality treated water, the microbial water quality may deteriorate during water distribution due to the regrowth and aftergrowth of bacteria and the formation of biofilms. The formation of biofilms is one of the main reasons for the deterioration of the bacteriological water quality during distribution. Several factors influence the formation of biofilms within DWDNs and these factors include the type of disinfectants used, maintaining the correct residual concentration, the nature and concentration of natural organic matter (NOM) presence, temperature, and pH, the nature and age of pipe materials, water aging, and hydraulic conditions. The biofilms play a significant role in DWDNs as they impact the disinfectant residual concentration in water, reduce dissolved oxygen, and provide shelter for pathogenic bacteria and other important bacteria like nitrifiers. Recent research has discovered that biofilms serve as precursors for forming disinfectant by-products (DBPs). As Sri Lanka is a tropical country, favorable water temperature and NOM promote microbial growth and the formation of biofilms. Furthermore, the rise in water temperature and biodegradation of NOM in source water is closely related to climate change. Therefore, it is important to thoroughly investigate the diversity of biofilms in distribution lines, in tropical countries like Sri Lanka. However, the occurrence and persistence of pathogenic and opportunistic bacteria associated with biofilms, as well as the transmission of antibiotic-resistant genes (ARGs) through drinking water biofilms are inadequately explored in Sri Lanka. Consequently, this study aims to examine the significance of characterizing biofilm-associated bacteria in DWDNs. This discussion provides an overview of the initial findings from an ongoing study. Upon analyzing a freshly obtained biofilm sample from an aged pipeline of a distribution network, a substantial number of bacterial colonies were observed on nutrient agar, following the standard methods. Further analysis of these bacterial colonies revealed the presence of the *sul1* gene. These preliminary data highlight the importance of comprehensively examining the diversity of biofilms in DWDNs, under the various influential factors that contribute to biofilm formation within DWDNs.

Keywords: Biofilms; Drinking water distribution networks; Pathogenic bacteria; ARGs

ICSBE 2023-375

FLUORESCENCE CHARACTERISTICS OF DISSOLVED ORGANIC MATTER IN GROUNDWATER AND SURFACE WATER IN TANK CASCADE SYSTEMS IN THE DRYZONE OF, SRI LANKA

S. Indika[1, 2], Y.S. Wei[1, 2, 3, *], D.Z. Hu[1, 2], I. Yapabandara[1, 2], S. Athauda[2, 4], T. Cooray[5], M. Makehelwala[6], K.B.S.N. Jinadasa[7], S.K. Weragoda[6, 8], R. Weerasooriya[3]

[1] Laboratory of Water Pollution Control Technology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, 100085, China.

[2] University of Chinese Academy of Sciences, Beijing, 100049, China.

[3] National Institute of Fundamental Studies, Kandy, 20000, Sri Lanka

[4] State Key Laboratory of Environmental Chemistry and Ecotoxicology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, 100085 China.

[5] Department of Applied Earth Sciences, Uva Wellassa University, Badulla, 90000, Sri Lanka.

[6] China-Sri Lanka Joint Research and Demonstration Center for Water Technology, Ministry of Water Supply, Meewathura, Peradeniya 20400, Sri Lanka.

[7] Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Peradeniya, 20400, Sri Lanka

[8] National Water Supply and Drainage Board, Katugastota, 20800, Sri Lanka.

*.*Correspondence E-mail: yswei@rcees.ac.cn, TP: +86-10-62849690*

Abstract: Investigation of the surface and groundwater quality along the river basins, which pass through different land use patterns and are subjected to different hydrogeochemical processes has been a key topic of recent research studies. In this study, the characteristics of dissolved organic matter (DOM) within the several cascades of manmade tanks (VTCs) located along an ephemeral river basin (Mahakanadarawa basin), and its relationship with water quality, were analyzed using the parallel factor (PARAFAC) analysis and spatial interpolation maps. PARAFAC analysis showed that DOM in the tank and shallow groundwaters contains five distinct fluorescence components. Shallow groundwater has fluorescence components such as Terrestrial Humic like C1: 25.2% and C3:16.2%, , Microbial fresh like C2: 24.4%, protein like C4:14.8% and Fulvic like C5:19.7% while Tank water was having C1:35.76%, C3:11.83%, C2:30.72%, C4: 11.55% and C5:11.26% acordingly. This observation reveals the dominancy of humic-like and microbial organic matter in the natural waters. DOC level in this basin showed that tank waters are more organically polluted than shallow groundwaters at the end of the wet season. Having an elevated fluorescence index (FI) value reveals the dominant microbial-originated fresh-like organic matter in both tanks (FI >1.7) and shallow groundwaters (FI >2.0). However, tanks with the highest DOC level showed the lowest FI values while indicating that DOC increases could be due to the mixing with terrestrial organic carbon that comes with the runoff water which originates from the forests and higher elevation rainfed Chena cultivation lands in the basin. Shallow groundwater in higher elevation regions showed the highest FI values indicating the dominant fresh-like DOM while the lower section of the cascade was dominated by terrestrial-originated DOM. Hence, a spatial evolution of the DOM pattern could be observed along these TCSs. The presence of TCSs helps to degrade the DOM toward the drainage direction of water within TCSs. Thus, TCSs play a huge role in recycling DOM which comes with the agricultural runoff from higher elevations of the basin.

Keywords: Tank Cascade System; Dissolved organic matter; Fluoracense index; Terrestrial organic matter; Fresh-like organic matter

ICSBE 2023- 377

TEMPORAL AND SPATIAL DYNAMICS OF WATER QUALITY PARAMETERS IN BEIRA LAKE: SEASONAL VARIATIONS AND ECOLOGICAL IMPLICATIONS

Sangeeth Prasad[1,2,3], Yuansong Wei [1,2,3*], Tushara Chaminda [4], Tharindu Ritigala[5,6], Suresh Indika[1,2,3], Isuru Yapa[1,2,3], Sujithra.K. Weragoda[7,8], Madhubhashini Makehelwala[7]

[1] State Key Joint Laboratory of Environmental Simulation and Pollution Control, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China.

[2] Laboratory of Water Pollution Control Technology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

[3] University of Chinese Academy of Sciences, Beijing 100049, China.

[4] Faculty of Engineering, University of Ruhuna, Hapugala, Galle 80000, Sri Lanka

[5] Beijing Enterprises Water Group, BEWG Building, Wangjingdongyuan, Chaoyang District, Beijing,100102

[6] Beijing Enterprises Water Group, Gaborone, Botswana

[7] China-Sri Lanka Joint Research and Demonstration Center for Water Technology, Ministry of Water Supply, Sri Lanka.

[8] National Water Supply and Drainage Board, Katugastota, 20800, Sri Lanka.

**Correspondence E-mail: yswei@rcees.ac.cn , TP: +86-10-6284-9690*

Abstract: In response to a century-long history of anthropogenic impact, Beira Lake in Colombo, Sri Lanka, underwent a comprehensive study. Despite past efforts to restore its health, these endeavors fell short due to a lack of thorough comprehension regarding pollutant dynamics within the lake. Focused on understanding pollutant dynamics, this investigation aimed to assess water quality using diverse physicochemical parameters and numerical indices. The study's objective was to unravel spatial-temporal variations of Beira Lake's water quality, which are crucial for comprehending and addressing the lake's ecological challenges. In Gangarama Lake areas, COD consistently exceeds 15 mg/L in both seasons, potentially impacting DO levels. All the lakes have exceeded the standard COD value of 15mg/L in both seasons, while it is significantly high in the dry season. pH levels surpass recommended limits during the dry season, reaching values between 9.4 and 10.4, depicting an alkaline environment. Notably, the range in the wet season stays within acceptable limits, fluctuating from 7.5 to 8.2. Electrical Conductivity (EC) and Total Dissolved Solids (TDS) demonstrate marked variations. EC values peak during the wet season, reaching up to 557µs, while TDS follows a similar pattern, with the highest values recorded at 306.4 mg/L in the wet season and mean values around 206.2 mg/L. Nutrient ions like Total Nitrogen (TN) and Nitrate Nitrogen showcase noteworthy seasonal differences. TN levels spike in the wet season (29.54 mg/L in Galle Face Lake), while nitrate nitrogen exceeds 30 mg/L in both dry and wet seasons in certain areas. Temperature fluctuations within the lake are apparent, with higher ambient temperatures observed in the dry season (35.9 °C) compared to the wet season (28.8 °C). Heavy metals, notably Mercury (Hg), show marked fluctuations, with concentrations rising notably in the dry season (1.71 µg/L), potentially influenced by various sources, including industrial activities and waste discharge. Immediate action is vital to curb Beira Lake's water pollution and degradation. Implementing sewage interception, buffer zones, filtering units, and wetlands is crucial to tackle nutrient and heavy metal pollution, emphasizing sustainable practices and ongoing monitoring for the ecological balance and sustainability of Beira Lake's ecosystem.

Keywords: Beira Lake; Water Quality; Anthropogenic Impact; Spatial-temporal variation; Sri Lanka

ICSBE 2023-371

DETECTION OF *CRYPTOSPORIDIUM* AND CORONAVIRUS IN INFLUENT AND EFFLUENT WATER IN SELECTED WATER TREATMENT PLANTS ALONG THE MAHAWELI RIVER IN KANDY DISTRICT

F. Fareed[1,2], F. Noordeen[1], P.T.A. Thilakarathna[1,2], T.N. Premachandra[3], S.K. Weragoda[3], Yuansong Wei[4], Zhang Yu[4], Min Yang[4] and S.H.P.P. Karunaratne[1]

[1]University of Peradeniya, Peradeniya, Sri Lanka.

[2]Postgraduate Institute of Science, Peradeniya, Sri Lanka.

[3]China-Sri Lanka Joint Research and Demonstration Centre for Water Technology, Meewathura, Peradeniya, Sri Lanka.

[4]Research Centre for Eco-Environment Sciences, Chinese Academy of Sciences, Beijing, China.

Abstract. Mahaweli river serves as the primary source of drinking water in Kandy and its surrounding areas. Contamination of river water with pathogens, including protozoa and viruses, originating from sewage discharge from sources like hospitals, livestock farms, and domestic drainage systems, poses a significant health risk to the consumers. Analysis for *Giardia* and *Cryptosporidium* was conducted at eight major Water Treatment Plants (WTPs) in the Kandy District and one in the Nuwara-Eliya District in July 2023. Analysis for coronavirus (CoV) was done at two WTPs. At each WTPs, 50L of both influent and effluent water were filtered through an apparatus consisting a plastic filter holder equipped with a yarn-wound polypropylene filter with 1 µm porosity. Filter cartridges were transported at 4 °C to the laboratory. Where they were washed vigorously to elute the spores into phosphate buffer saline (PBS), filtered again through a 0.45 µm filter and eluted to 5 mL of PBS. To detect *Giardia*, 100 µl was stained with a drop of Lugol's iodine. To detect *Cryptosporidium,* 200 µl was stained using modified Ziehl-Neelsen technique and examined under oil immersion microscopy. To detect CoV, 5-liter samples of both influent and effluent water were filtered through 1 µm followed by 0.22 µm filters. RNA was extracted using bead beating RNA extraction kit and the virus amplicon was obtained by conventional PanCoV nested RT-PCR, and visualized using agarose gel electrophoresis. *Giardia* was not detected in any of the tested water samples. *Cryptosporidium* was detected in treated water from Paradeka and Kandy South, as well as in influent samples from Nanu-oya, Paradeka, Kandy South, University Plant, Polgolla, Haragama, and Balagola. Only one sample (University WTP influent water) showed the correct band size for the intended CoV fragment. The findings indicate that Mahaweli water is contaminated with faeces from both humans and animals. *Cryptosporidium* oocysts can survive with the chlorine dosage applied in the conventional water treatment process. Identification of CoV in the water signifies its existence in river water sources. Comprehensive and extended studies on these protozoan and viruses are essential to improve the treatment process at WTPs.

Keywords: *Cryptosporidium,* Coronavirus (CoV), Mahaweli river, Water treatment, Kandy

ICSBE 2023-370

DIVERSITY AND ANTIBIOTIC RESISTANCE OF HETEROTROPHIC BACTERIA IN DRINKING WATER: A STUDY ALONG THE MAHAWELI RIVER WATER TREATMENT PLANTS FROM KOTAGALA TO BALAGOLLA

P.T.A. Thilakarathna[1,2], S. Athukorala[1], F. Fareed[1,2], R.N. Jinadasa[1], T.N. Premachandra[3], M. Makehelwela[3], B.R. Fernando[1], S.K. Weragoda[3], Yawei Wang[4], Zhang Yu[4], Min Yang[4] and S.H.P.P. Karunaratne[1]

[1]University of Peradeniya, Peradeniya, Sri Lanka.

[2]Postgraduate Institute of Science, Peradeniya, Sri Lanka.

[3]China-Sri Lanka Joint Research and Demonstration Centre for Water Technology, Meewathura, Peradeniya, Sri Lanka.

[4]Research Centre for Eco-Environment Sciences, Chinese Academy of Sciences, Beijing, China.

Abstract: Drinking water contamination is a critical and significant concern that is particularly prominent in developing countries. Water distribution systems have the potential to act as major reservoirs for the dissemination of antibiotic-resistant, opportunistic pathogens to the human body. This study examined the diversity and antibiotic resistance of bacterial populations isolated from drinking water prepared for dissemination by water treatment plants (WTPs) of Mahaweli river. Treated water samples (after chlorination) (42) were collected from 14 WTPs situated along the Mahaweli River between Kotagala and Balagolla in September 2022, February and July 2023. Bacteria were isolated by standard plate technique on nutrient agar according to American Public Health Association (APHA) guidelines. The isolates with distinct colony morphologies were subjected to Gram staining and relevant biochemical assays to ascertain the genera of the bacterial population in collected drinking water. Antibiotic resistance for amoxicillin (AMX), tetracycline (TE), ciprofloxacin (CIP), cefuroxime (CXM), and ceftazidime (CAZ) were ascertained using Kirby and Bauer disc diffusion method outlined by the Clinical and Laboratory Standards Institute (CLSI).

Out of the 135 isolates, *Micrococcus* spp. and *Staphylococcus* spp. were predominant constituting 25.7% and 74.3% of the bacterial population respectively. Gram negative bacteria were absent. In the bacterial population, 82.9% (n = 112) showed resistance to at least one tested antibiotic. The highest percentage (62.2%, n = 76) of resistance was detected for CAZ. Conversely, resistance to CXM and TE was observed in only 6.7% (n = 9) and 8.1% (n = 11), respectively. Resistance percentages for AMX and CIP were 43.7% and 56.3% respectively. Furthermore, 29.6% (n = 40) demonstrated multi antibiotic-resistance (MAR) by illustrating the resistance to more than two antibiotics. In 8.9% (n = 12) isolates, resistance to more than four tested antibiotics was detected. The study shows a concerning level of resistance to commonly used antibiotics within the bacterial population. The bacteria acquiring antibiotic resistance are more prone to survive after the water treatment. The findings of the study also highlighted the critical requirement of comprehensive monitoring and intervention plans at water treatment facilities in order to reduce the spread of bacterial resistant to antibiotics through drinking water.

Keywords: Antibiotic resistance; Bacteria diversity; Drinking water; Mahaweli river; water treatment plants.

ICSBE 2023-374

OPTIMIZATION STRATEGY OF GRAVITY-DRIVEN MEMBRANE FILTRATION BASED ON MICROBIAL RISK CONTROL IN PERMEATE

Qingke Yuan[1], Hao Zhao, Yanfeng Liu, Ying Meng, Fubo Luan*

[1]Key Laboratory of Drinking Water Science and Technology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, PR China.

**Correspondence E-mail: fbluan@rcees.ac.cn, TP: +8601062911779*

Abstract: Harvesting rainwater for potable use is an alternative approach to solve the drinking water problem in Sri Land, while the gravity-driven membrane (GDM) is key purification technology to ensure the rainwater quality to meet drinking water requirement. This study aims to evaluated the microbiological risk in the effluent of a GDM filter during long-term operation, thereby, investigating the relationships between the design parameters of the hollow fiber membrane module (including fiber material, pore size, and fiber length) and the microbial counts in the effluent. The results suggests that different design parameters significantly impacted the microbial indicators of GDM effluent. The membranes with higher hydrophilicity (modified PVDF) and smaller pore size (20 nm) had lower microbial counts in the effluent. By optimizing the design parameters of the fiber module, the biological safety risk of GDM effluent can be reduced to ensure safe drinking water.

Keywords: Gravity-driven membrane filtration; Membrane module design parameters; Microbiological risk management; Rainwater purification

ICSBE 2023 -378

ANALYSIS OF MEMBRANE FOULING CHARACTERISTICS AND CLEANING STRATEGIES OF NANOFILTRATION PLANT WITH DECENTRALIZED WATER SUPPLY FROM RURAL GROUNDWATER SOURCES

HU Da-zhou[1,2,3], SURESH-Indika[1,2.3], WEI Yuan-song [1,2.3]

[1] State Key Joint Laboratory of Environment Simulation and Pollution Control, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 10085, China.

[2] Laboratory of Water Pollution Control, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China.

[3] University of Chinese Academy of Sciences, Beijing 100049, China.

**Correspondence E-mail: yswei@rcees.ac.cn, TP: +86-18601952413*

Abstract: Decentralised water supply plants with rural groundwater as the source were examined to monitor water quality during the life cycle of the nanofiltration membranes, and the fouling morphology, scaling composition and characteristics of the nanofiltration membranes in the water stations were studied. The results show that: nanofiltration membrane surface contaminants are mainly irreversible fouling, the fouling layer exists in the form of inorganic-organic composite fouled, and there are differences in the main fouling fouling in different sections. In the inlet and middle sections, organic fouling is predominant. In the outlet section, which is dominated by inorganic fouling. Dacy's law calculations showed inorganic fouling resistance of 2.08 x 10^{13} m^{-1} which is 39.32 % of the total resistance and organic fouling resistance of 1.23 x 10^{13} m^{-1} which is 23.25 % of the total resistance, respectively. Different gradient cleaning agents were used to clean the contaminated membrane, and the results showed that acid cleaning was better than alkaline cleaning, and the cleaning method of "acid + alkaline " could obtain a more recovery flux.

Keywords: Decentralised water supply; Nanofiltration membranes; Fouling layer

ICSBE 2023-379

CHARACTERISTICS OF DISSOLVED ORGANIC MATTERS IN THE TREATMENT OF THE DEWATERING LIQUOR OF ANAEROBIC DIGESTION PRETREATED BY THERMAL HYDROLYSIS

YUE Wen-hui[1,2,3], LIU Ji-bao[1,2], GUO Jian-ning[4], WEI Yuan-song[1,2,3], SUI Qian-wen[1,2]

[1] State Key Joint Laboratory of Environment Simulation and Pollution Control, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 10085, China.

[2] Department of Water Pollution Control, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China.

[3] University of Chinese Academy of Sciences, Beijing 100049, China.

[4] Shenzhen Institute of Information Technology, Shenzhen 518172, China.

**Correspondence E-mail: yswei@rcees.ac.cn, TP: +86-10-62849690*

Abstract: In the dewatering liquor of anaerobic digestion (**AD**) pretreated by thermal hydrolysis process (THP), there were higher organic and nitrogen pollutants than in traditional anaerobic digestate. Higher organic loading and the recalcitrance of dissolved organic matters (DOM) in THP-AD centrate restricted the popularization and application of the sludge treatment by THP-AD. Therefore, a full-scale THP-AD centrate treatment plant was systematically analyzed in this study. And results showed that the process of 'biological pretreatment + two-stage AO + MBR' achieved efficient nitrogen removal (TN removal rate of 90.2%) and general COD removal (69.9%). Most of DOM removal relied on membrane filtration (184.7%), while the contribution proportion of biological pretreatment to organic matter removal was only 18.2%. High molecular weight biopolymer was the main component of the intercepted organic matter, followed by humic substance. The humification degree of effluent increased, and the main residual DOM was fulvic acid and humic acid. The three existing cleaning methods with water, acid and base showed similar cleaning effects on organic pollution, while low molecular weight organic matter accounted for 89.1% in the cleaning solution.

Keywords: Anaerobic sludge digestion; Dissolved organic matter (DOM); Humics; Organic component; 3D-EEM

ICSBE 2023-384

A COMPREHENSIVE STUDY ON APPLICABILITY AND OPTIMIZING ED DOMESTIC TREATMENT PLANTS FOR GROUNDWATER REVITALIZATION IN THE CKDu-AFFECTED DRY ZONE OF SRI LANKA

M.D.D.R. Gunathilake [1], Y.D. Kahatapitiya [1], B.K.R.S. Wanshanatha[1], R.M.C.P. Rathnayaka [1], T.P. Malalagama[2], M. Makehelwala[1], S.K. Weragoda[1], Binghui Tian[2*]

[1] China Sri Lanka Joint Research and Demonstration Center for Water Technology, Peradeniya, Sri Lanka.

[2] State Key Laboratory of Enviromental Aquatic Chemistry, Research Center for Eco-Enviromental Sciences, University of Chinese Academy of Sciences, Chinese Academy of Sciences, Beijing 100085, China.

**Correspondence E-mail: tianbh@rcees.ac.cn*

Abstract: Groundwater predominates as the main source of drinking water in Sri Lanka and considered to be a critical concern within high prevalence chronic kidney disease of Unknown etiology (CKDu) areas. Hardness and salinity of groundwater in these regions reported in higher range. Therefore, residents are reluctant to use water from their nearby water sources due to both safety and palatability concerns. Ensuring readily available safe drinking water at residents' doorsteps could be a practical solution. ED (Electro Dialysis) technology emerges as an effective solution for groundwater treatment due to its cost effectiveness and higher recovery rate compared to other methods including RO and NF. The applicability of ED water treatment technology to households for treating groundwater has been tested for the first time in Sri Lanka. Removal of anions, specifically fluoride, chloride, nitrate, sulphate alongside hardness, alkalinity and Total Dissolved Solids (TDS) were studied. The optimal voltage selection was mainly studied based on hardness and fluoride. Initial parameter optimization was conducted using laboratory prepared synthetic water to mimic groundwater concentrations in dry zone and fed to filtration setup at varying voltages and time frames. Treatment performed within 30 minutes is excluded based on the suboptimal efficiency and 60 minute duration was focused. The overall removal efficiency of the anions observed as Nitrate>Fluoride>Sulphate>Chloride. Subsequently, an optimum voltage is identified as in the range of 9V to 9.4V based on a mathematical approach, considering both the removal efficiency and effect of the concentrated polarization. The findings from this study were then applied to real groundwater conditions adjusting filters at 9.2V. As a result, 85% and 76% of removal efficiency were achieved in hardness and fluoride, respectively. The proven effectiveness of household ED in groundwater treatment can gain momentum in the future, delivering safe and accessible drinking water directly to people's doorsteps.

Keywords: Electro Dialysis; CKDu; Groundwater treatment; Operational parameter optimization.

ICSBE 2023-380

POWDERED ACTIVATED CARBON-CATALYZED MN(II) REMOVAL BY FREE CHLORINE FOR CONTROLLING DRINKING WATER DISCOLORATION PROBLEMS

G. Li[1]*, 1B. Shi[1]**

[1]*Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China*

**Correspondence E-mail:* gwli@rcees.ac.cn, byshi@rcees.ac.cn

Abstract: Drinking water discoloration is one of the most common customer complaints. The accumulation of residual manganese (Mn) in drinking water distribution systems (DWDS) accounts for part of the discolored water that reaches household taps. Chlorine is not effective in the oxidative removal of soluble manganese(II) ions at neutral pH. Powdered activated carbon (PAC) also has a very limited capacity for Mn(II) removal through adsorption in drinking water treatment practice. This study explored the combined use of PAC and chlorine for Mn(II) removal and found that PAC dramatically catalyzed Mn(II) oxidation by chlorine under diverse conditions. At a dose as low as 5.0 mg/L, two different commercial PACs increased Mn(II) oxidation rate by two orders of magnitude respectively and reduced Mn(II) concentration from 200 μg/L to < 10 μg/L in tens of minutes. First-order kinetics with respect to aqueous Mn(II) concentration were observed. Typically, homogeneous Mn(II) oxidation by chlorine depends strongly on alkaline pH. In the presence of PAC, however, the reaction was still rather fast at pH 6.0. Increasing PAC doses linearly increased Mn(II) oxidation rate, indicating that the reaction was highly PAC surface active sites dependent. The efficacy of PAC was further corroborated in removing Mn(II) from natural water. SEM-EDS and XPS demonstrated that a MnO2 coating was formed on PAC surface after reaction, which resulted from heterogeneous oxidation of Mn(II) on PAC surface rather than the precipitation of Mn oxides formed through homogeneous oxidation in solution. Adsorption of free Mn(II) ions onto PAC surface was proved to directly correlate with Mn(II) oxidation rate. Two kinds of electron transfer pathways from adsorbed Mn(II) species to chlorine, enhanced by surface-complexation and electrically-conductive carbon surface respectively, were hypothesized.

Keywords: Manganese(II) oxidation; Powdered activated carbon; Chlorine; Discoloration; Drinking water quality

ICSBE 2023-381

INTEGRATION OF SULFAMMOX AND SULFIDE-DRIVEN AUTOTROPHIC DENITRIFICATION (SDAD) PROCESSES IN ANAEROBIC MBR FOR TREATING RUBBER INDUSTRY WASTEWATER WITH HIGH AMMONIA AND SULFATE

T.I.P. Wimalaweera [1,2,3], F. Zuo[1,2,3], Q.Tang[1,2,3], K.B.S.N. Jinadasa [5], S.K. Weragoda[6,7], T. Ritigala [1,2,3], R. Weerasooriya[4], M. Makehelwala[6] , and Y.S. Wei [1,2,3,4*]

[1] State Key Joint Laboratory of Environmental Simulation and Pollution Control, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

[2] Laboratory of Water Pollution Control Technology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

[3]Chinese Academy of Sciences, Beijing 100085,China.

[4] National Institute of Fundamental Studies, Hanthana Road, Kandy 20000, Sri Lanka

[5] Department of Civil Engineering, University of Peradeniya, Peradeniya 20400, Sri Lanka

[6]China-Sri Lanka Joint Research and Demonstration Center for Water Technology, Ministry of Water Supply, Meewathura, Peradeniya 20400, Sri Lanka

[7] National Water Supply and Drainage Board, Katugastota 20800, Sri Lanka;

**Correspondence E-mail: yswei@rcees.ac.cn; TP: +86-10-6284-9690*

Abstract: The synergistic utilization of sulfammox and sulfide-driven autotrophic denitrification (SDAD) processes holds significant promise for environmentally friendly and sustainable applications. This integration was employed in a single reactor system to treat wastewater from the natural rubber industry, featuring high concentrations of NH_4^+-N (1545.0 ± 96.5 mg/L) and SO_4^{2-}-S (425.0 ± 180.5mg/L) using an anaerobic membrane bioreactor (AnMBR reactor). Over 225 days of continuous operation, the AnMBR system achieved removal efficiencies of 46.8%, 17.6%, and 44.9% for COD, total nitrogen, and sulphate, respectively. In this context, SO_4^{2-}-S served as an electron acceptor for NH_4^+-N oxidation in anaerobic conditions, demonstrating enhanced nitrogen removal efficiency through the sulfammox process. Sulphide, present both in the influent and generated by sulphate-reducing bacteria, serves as an electron donor to drive denitrification through the SDAD process. The varying NH_4^+-N / SO_4^{2-}-S ratios showed the integrative role of SO_4^{2-}-S in the nitrogen and sulphur cycles. The predominance of *Desulfovibrio* and *Sulfurospirillum* as functional microorganisms in the sulfammox and SDAD processes underscores their significance. This innovative approach of sulfammox and SDAD presents a sustainable and energy-efficient solution for treating wastewater with high ammonia and sulphate content.

Keywords: Anaerobic Membrane Bioreactor; Rubber Industry; Sulfammox; Sulphide Driven Autotrophic Denitrification; Industrial Wastewater

ICSBE 2023-372

ACHIEVEMENTS AND EXPERIENCES OF CHINESE INDUSTRIAL PARK ECOLOGICAL DEVELOPMENT

Jingru Liu

Shuangiqng Road, Haidian District, Beijing, 100085

**Correspondence E-mail: liujingru@rcees.ac.cn. TP: +86-10-62849110*

Abstract: I Since the beginning of China's reform and opening-up, development zones have played a crucial role in attracting foreign investment and advanced technology, making them important platforms for land exploration, economic development, and management policies. Initially, these zones were known as export processing zones or special economic zones. The success of the Shekou Export Processing Zone in 1979 led to the establishment of the National Development Zone Office by the State Council, which aimed to develop models and policies for the nationwide expansion of development zones. Currently, there are 551 national-level development zones and 1991 provincial-level development zones recognized by the State Council in China. In response to the dual pressures of supporting industrial economic development and addressing environmental issues, the concept of eco-industrial parks was introduced to China in 1998. It was quickly embraced by environmental protection departments as an effective model for achieving a win-win situation for the economy and the environment. The strong promotion from the central government down to local levels facilitated the rapid adoption, adaptation, and innovation of this imported concept. This article attempts to summarize and analyze the patterns and experiences that have emerged from 20 years of eco-industrial park practices in China, and provide new ideas and suggestions for the ecological construction of parks in the next phase.

Keywords: Development zones; Industrial park; Eco-industrial parks; Environmental mangement

ICSBE 2023-373

EFFECTS OF DRINKING WATER FLUORIDE AND HARDNESS ON BOVINE SERUM BIOCHEMICAL PROPERTIES IN HIGH CKDU PREVALENCE AREAS IN SRI LANKA UNDER ONE HEALTH APPROACH

H.M.S. Wasana[*1,2,3], G.D.R.K.Perera[4], I.A.M.P. Ileperuma[4,5], H.T.K. Abeysundara[6], L. Jayarathne[7], Youngsong Wei [1,7]

[1] Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China

[2] Postgraduate Institute of Agriculture, University of Peradeniya Sri Lanka

[3] China - Sri Lanka Joint Research and Demonstration Center for Water Technology, Ministry of Water Supply, Peradeniya, Sri Lanka

[4]Postgraduate Institute of Science, University of Peradeniya, Sri Lanka

[5] Department of Farm Animal Production and Health, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Sri Lanka

[6] Department of Statistics and Computer Science, Faculty of Science, University of Peradeniya

[7]National Institute of Fundamental Studies, Hanthana Rd,Kandy, Sri Lanka

**Correspondence E-mail: wasana@rcees.ac.cn / wasanahms@gmail.com*

Abstract: Chronic Kidney Disease of uncertain etiology (CKDu) is a growing concern in agricultural communities in Sri Lanka and other hotspots worldwide. Elevated concentrations of fluoride ions, hardness, and ionicity/electrolytes in groundwater is suggested to be linked to CKDu in humans. However, no research has explored yet the effects of drinking water exposures on CKD/CKDu prevalence for animals, particularly cattle populations living in high CKDu prevalence areas under one health approach. This research work aimed to study the association of drinking water fluoride and hardness levels on four selected bovine serum biochemical properties with respect to their kidney functions in high CKDu prevalence areas in Anuradhapura district vs. control areas in Kandy district. A total of 83 milking cows (50 test group and 33 control) and 83 water samples were analyzed in this study. Water samples were analyzed for fluoride and hardness levels. Results showed that Serum Creatinine (SCR), Blood Urea Nitrogen (BUN), and Total Protein (TP) values were significantly higher ($P<0.01$) for the test group than the control group, while Serum Albumin (SAL) levels were significantly lower ($P<0.01$) for the test group. The percentage of test samples laid outside the standard interval for healthy subjects was 100% for all four biochemical properties. Pearson correlation analysis between water quality variables and biochemistry measurements indicated significant positive correlations ($P< 0.05$) with F and Hardness levels for SCR and TP, except for Hardness Vs. BUN for the test group compared to control group. SAL was significantly ($P< 0.05$) negatively correlated with Hardness and Fluoride. According to the results, it was indicated 'Hypoalbuminemia', 'hyperproteinemia,' elevated levels of BUN and SCR associated with inflammation suggesting chronic nephritis conditions in cows (*similar to indications reported in the CKDu patients in high CKDu prevalence areas*), correlated with high F (Avg 1.2 mg/L) and Hardness (Avg 167 mg/L) levels in drinking water belong to the test group compared to the control group. Further research is recommended to address the public health and animal welfare concerns.

Keywords: Bovine, CKDu, Fluoride; Harness; One Health; Serum Biochemistry.

ICSBE 2023-382

INVESTIGATING THE HYDROCHEMICAL COMPOSITIONS AND EVOLUTION OF GROUNDWATER DUE TO THE INFLUENCE OF SEAWATER INTRUSION IN THE MANNAR DISTRICT, SRI LANKA

Samadhi Athauda [1,2], Yunwen Wang [1,2], Zhineng Hao [1,2*], Suresh Indika [2,3], Isuru Yapabandara [2,3], Sujithra K. Weragoda [4,5], Jingfu Liu[6] and Yuansong Wei[2,3,4*]

[1] State Key Laboratory of Environmental Chemistry and Ecotoxicology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

[2] University of Chinese Academy of Sciences, Beijing 100049, China

[3] State Key Joint Laboratory of Environmental Simulation and Pollution Control, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

[4] China-Sri Lanka Joint Research and Demonstration Center for Water Technology, Ministry of Water Supply, Meewathura, Peradeniya 20400, Sri Lanka

[5] National Water Supply and Drainage Board, Katugastota 20800, Sri Lanka

[6] Institute of Environment and Health, Jianghan University, Wuhan 430056, China

**Correspondence E-mail: znhao@rcees.ac.cn (Zhineng Hao) TP: +8618810015928, yswei@rcees.ac.cn (Yuansong Wei), TP: +861062849690*

Abstract: Coastal groundwater quality is vital for drinking water and sustainable development, but the seawater intrusion severely impacts its hydrochemistry and evolution. This study focuses on analyzing the hydrochemical compositions, water quality, and evolution processes of groundwater in the Mannar district of Sri Lanka during the dry season. A total of 56 samples were collected from shallow and tube wells across the region for analysis. The results show that the major ions in tube well had a higher content than in shallow well, with higher overall content in the south mainland regions of Mannar district. About 64.28% of groundwater samples had good quality (WQI < 100). Seawater intrusion significantly affected 51.28% of shallow well groundwater and 70.58% of tube well groundwater, respectively. HCO_3-Ca and Cl-Na facies were the predominant hydro chemical type in rock weathering-evaporative crystallization area, with 74.36% and 64.71% of freshening phases as well as 25.64% and 35.29% of intrusion phases for shallow well and tube well groundwaters, respectively. The study concludes that hydrochemical compositions of groundwater in the Mannar region are affected by seawater intrusion, mineral dissolution, rock-water interaction, and ion exchange, which influence groundwater evolution. Our work would help understand the impact of seawater intrusion on hydrochemical compositions and evolution processes of groundwater, and calls for sustainable groundwater management and treatment in the area.

Keywords: Groundwater; Hydrochemical composition; Water quality; Spatial-temporal mapping.

ICSBE 2023- 383

FOULING MECHANISMS AND EFFECTIVE CLEANING STRATEGIES FOR ELECTRODIALYSIS DISTILLATION IN BRACKISH GROUNDWATER TREATMENT

Malalagama T.P.[1*], Binghui Tian [1], Gunathilake M.D.D.R.[2], Min Yang [1]

[1] State Key Laboratory of Environmental Aquatic Chemistry, Research Center for Eco-Environmental Sciences, University of Chinese Academy of Sciences, Chinese Academy of Sciences, Beijing 100085, China.

2 China-Sri Lanka Joint Research and Demonstration Center for water Technology, Ministry of Water Supply, Meewathura, Peradeniya 20400, Sri Lanka

**Correspondence E-mail: tianbh@rcees.ac.cn*

Abstract: The global scarcity of potable water imposes significant health and economic burdens on populations worldwide and interest on groundwater treatment was emerged in recent past. EDR technology received attention as a solution for groundwater treatment due to numerous advantages. Still EDR technology faced with the difficulty of fouling which hinder the performance of the system. In this study the mechanisms of membrane fouling and scaling was investigated using various spectrum analysis approaches. Study was further extended to explore the impact of chemical cleaning on the elimination of foulant and scale, with the objective of determining an appropriate membrane cleaning protocol. Our in-depth surface analyses of fouled membrane samples unveil a dual-stage fouling process: an initial compacted fouling layer primarily composed of organic matter is succeeded by the development of alkaline scaling. The principal inorganic foulants found on the membrane surface, including calcium, magnesium, and silicon are identified. Additionally, FTIR analysis confirms the presence of carbonate fouling, specifically $CaCO_3$. Subsequent evaluation of cleaning effectiveness encompasses four distinct methods. Traditional physical cleaning methods like deionized water and base solution cleaning with sodium hydroxide prove inadequate against alkaline scaling during membrane cleaning. In contrast, acidic solutions, particularly hydrochloric acid and acetic acid, exhibit promise in effectively addressing this type of scaling. Although complete removal of the gel layer remains a challenge, acetic acid emerges as a promising agent for combating membrane fouling in the context of EDR desalination. Our study underscores the insufficiency of relying on a single cleaning method to combat mixed fouling on membranes, advocating for a holistic approach employing a combination of cleaning methods. These findings offer valuable theoretical insights into the understanding of membrane fouling and the development of efficient cleaning strategies within the realm of brackish groundwater desalination using electrodialysis.

Keywords: Electrodialysis; Brackish groundwater; Scaling; Membrane fouling; Membrane cleaning; Calcium carbonate

ICSBE 2023-376

IMPACT OF ORGANIC FERTILIZER RATIOS ON MICROBIAL COMMUNITIES IN AGRICULTURAL RUNOFF: A FIELD SIMULATION STUDY

WANG Jinshi[1,2], HOU Yaojun[1,3], WANG Zhirong[1,2], WANG Yawei[1,4*], WEI Yuansong [1,4,5]

[1] Laboratory of Water Pollution Control Technology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

[2] School of Environmental Science and Safety Engineering, Tianjin University of Technology,Tianjin,300384,China

[3] College of Environmental Science and Engineering, Taiyuan University of Technology,Taiyuan 030600,China

[4] State Key Joint Laboratory of Environmental Simulation and Pollution Control, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China.

[5] University of Chinese Academy of Sciences, Beijing 100049, China.

**Correspondence E-mail: wangyawei@rcees.ac.cn , TP: +86-13522676276*

Abstract: The interplay between fertilizer usage and microbial dynamics in agricultural runoff is critical for understanding and managing environmental impacts of farming practices. This study aims to investigate the effects of varying organic-to-chemical fertilizer ratios on the structure of microbial communities in agricultural surface runoff under simulated rainfall conditions. The experiment was conducted outdoors with three different ratios of organic to chemical fertilizer (0:1, 3:5, 1:1). Runoff and soil samples were collected for analysis of their physicochemical properties. Metagenomic Sequencing Quantification was employed to examine the microbial community structures in both runoff water and soil. We observed significant initial fluctuations in the physicochemical properties of the runoff water, which stabilized over time. The study revealed that an increase in the ratio of organic fertilizer resulted in greater variations in microbial relative abundance. Specifically, the relative abundance of Proteobacteria, Actinobacteria, and Firmicutes showed substantial changes in response to moisture and rainfall. The highest loss of Pseudomonas spp. was noted in runoff water, while Streptococcus spp. dominated in soil, with its abundance increasing with higher organic fertilizer ratios. Additionally, we explored the release of pathogenic microorganisms with different fertilizer ratios and assessed the efficacy of single-parameter exponential and dual-parameter Bradford - Schijven models in simulating these releases. Our findings indicate the release of 41 pathogenic microorganisms following a 50-minute simulated rainfall, highlighting significant concentration disparities between manure and soil. This study underscores the importance of fertilizer management in agricultural practices and its influence on microbial dynamics in runoff. The results provide essential insights for the management of agricultural non-point source pollution, particularly concerning the release and distribution of pathogenic microorganisms in farm environments.

Keywords: Organic Fertilizer; Microbial Communities; Agricultural Runoff; Metagenomic Sequencing Quantification; Pathogenic Microorganisms.

URBAN LANDSCAPE ECOLOGICAL PLANNING SESSION

ICSBE 2023-5

THE ROLE OF COMMUNITY PARTICIPATION IN DISASTER RISK REDUCTION INITIATIVES WITH SPECIAL REFERENCE TO THE BATTICALOA CITY

Y. Arthy [1*]

[1] *Urban Development Authority, Sri Lanka.*

**Correspondence E-mail: arthy156@gmail.com, TP: +94774960221*

Abstract: Human beings as pioneering creatures have trailed novel behaviours in which to mitigate the awful effects of disasters. Anyhow, for years human behaviour regarding disasters has been responsive in nature. Communities, occasionally aware of the hazards that they encounter and they could wait in anticipation of a disastrous incidence and then activate approaches and activities. Disaster risk reduction (DRR) has become a strategy precedence worldwide and in line with this movement, the Sri Lanka Disaster Management Act and National Disaster Management Plan prioritize DRR in efforts to develop resilient communities with local municipalities being essential to build their own Disaster Management Agendas. The issue is that community participation is treated as of subordinate significance yet international agreements such as the Sendai Framework for Disaster Risk Reduction dynamically endorse community participation in DRR. A bottom-up approach is the most active in safeguarding effective DRR initiatives at the local scale since communities take possession of these initiatives and obtain a better empathetic of their risks. Community-based disaster risk reduction initiated in the paradigm move away from the contemporary disaster management method, moving away from responsive comebacks in the top-down approach in disaster risk management to more proactive responses. This research study discovered approaches used for community participation to safeguard effective DRR initiatives in Batticaloa city. The study is exploratory and descriptive, having used qualitative and quantitative research approaches, which included participatory approach. The results assembled from the data recommended that the role of community participation in DRR initiatives is effective in Batticaloa municipality because of the willingness of stakeholders to participate in DRR. Accordingly, it was recommended that community participation sessions should be conducted in order to create resilient cities and to challenge climate change in future.

Keywords: climate change; community participation; disaster risk reduction; participatory approach; resilient cities

ICSBE 2023-183

REUSE LEFTOVERS: PERSEPTIONS OF TOURISTS ON ADAPTIVE REUSE OF BUILDINGS AS HOTELS & CAFES

K.B Seenapatabendige*

Department of Architecture, Faculty of Built Environment and Spatial Science, Southern Campus, General Sir John Kotelawala

Defence University, Kiribbanwewa, Sooriyawewa, Sri Lanka.

**Correspondence E-mai: kbseenapatabendige@gmail.com*

Abstract: Natural beauty, culture and heritage are key factors in destination selection. Sri Lanka being a global tourist hotspot, creating competitiveness through unique approaches help industry's sustainability. Country with a fascinating history along with colonial intervention has created architectural masterpieces but limited research attention is paid on reuse of contemporary buildings. Main focus of the study was to identify the abandoned heritage buildings as tourist destinations and accommodations and to examine the tourist perceptions on reused buildings. Mixed method approach was instrumental in data collection. Site visits, walkthrough tour to identify building performance, analysis of the photographs, videos and online user satisfaction reviews were used to obtain tourist perceptions on reuse of heritage buildings. Case studies were performed in Heritance tea factory hotel, Lunugaga Estate, Paradise Road Tintagel and Paradise Road the Gallery Café, Golden Hill Tea Centre and the Bungalow Galle Fort representing hotels and restaurants. The study examined the technical elements (thermal comfort, visual comfort, acoustical comfort, indoor air quality, fire safety and plumbing services) and functional elements (interior and exterior finishes, furniture, distribution and layout inside of the building, power distribution and car parking). Sample profile comprised of 408 and 2838 traveller views on hotels and cafes respectively. The study revealed that the functional elements of the building spaces exhibited a significantly higher level of performance compared to the technical elements. Conservation and restoration of economically and culturally important but abandoned buildings through its adoptive reuse contributes to the enhancement of tourist attraction, liveability, tackle the challenges of resource scarcity, waste prevention and preserve heritage.

Keywords: Heritage buildings; Tourist perception; Adaptive Reuse; Sri Lanka

ICSBE 2023-193

THE ROLE OF CULTURAL VALUE IN SUSTAINABLE URBAN DEVELOPMENTS WITH SPECIAL REFERENCE TO THE FLOATING MARKET IN PETTAH

R.T.L.S. Rajapaksha [1*], N.L. Rubasin Gamage [1], H.P. Munasinghe [2]

[1]Kotelawela Defence University- Southern Campus, Edison Hill, Nugegalayaya, Sewanagala, Sri Lanka

[2]George Brown College, 160 Kendal Ave, Toronto, Canada

**Correspondence E-mail: laknasanda4@gmail.com, TP: +94 765732261*

Abstract: Urbanization is a global trend. In emerging nations like Sri Lanka, the non-visionary authorities have been attempting to replicate every eye-catching space they observe in other countries without incorporating it into our local culture. There are several examples of alienated urban developments that have become unsustainable built environments today in Sri Lanka. In terms of culture, planning for sustainable development entails more than just a typical roof or a symbol. It is the result of a coordinated effort involving correct planning in economic sustainability, environmental sustainability, and social sustainability. The floating market in *Pettah,* designed to promote both foreign and local tourism, has lost its appeal due to a lack of cultural offerings. Because In Sri Lankan history, there have never been any floating markets, and locals don't have any particular preference for using them. Cultural tourism is a key trend in encouraging sustainable tourism, but since there are no offerings in the market that accurately capture the spirit of Sri Lankan culture for foreign tourists, they don't find the market attractive like authentic floating markets In Southeast Asia. The market, which initially attracted crowds, has now been abandoned due to insufficient earnings, and a few stalls remain lucrative. In the future, we should steer clear of such urban idiocy. The research design aims to conduct the research in a sequential sequence of relevant steps to follow up on a standard research method to test the hypothesis by following the research objectives by generating a research framework from a Literature review, analyzing strengths, and weaknesses in major and minor case studies according to the research model, and assessing the results using a weighted analysis within their cultural base. The research findings have proposed the need to integrate cultural foundations into urban developments to make them a successful endeavor.

Keywords: Culture; Floating markets; Sustainability; Urban developments

ICSBE 2023-249

STUDY ON THE CONTRIBUTION OF ART IN ENHANCING THE PLACE ATTACHMENTS IN URBAN CONTEXT

R.R Samaratunge[1*], D. De Silva[1], J. Wijesundara [1]

[1]School of Architecture, Sri Lanka Institute of Information Technology.

**Correspondence E-mail: ranudisamaratunga@gmail.com, TP: +94740222375*

Abstract: With rapid urbanization and haphazard developments, the city character of urban contexts is degrading. As a result, the sense of place and place attachment of cities has degraded making them merely places that people pass by and people become less connected to cities, which makes it hard to have any memories of the city or remember the routes, etc. This research shall focus on Identifying how art can be used to enhance and develop the sense of place and how the intensity of place attachment varies through different artifacts. A thorough analysis is done to identify how to use these artistic elements to create place attachment and enhance the sense of place in urban contexts. The research is conducted by a qualitative analysis of primary data. Surveys are conducted to interview people in four urban contexts (Nugegoda, Pettah, Townhall, Kolpity). The survey consists of two parts, in the first part the people are asked to draw a mind map of the area. In the second part, they are given a follow-up questionnaire to identify and analyze the artistic elements that attach them to a place. Finally, this research shall conclude the ways to use artistic elements in an urban context to enhance and develop the sense of place and place attachment. Thus, how to connect people to an urban context through means of arts to improve the city's character and create a better connection between people and cities, leading to the design of sustainable cities.

Keywords: Urban art; Artistic elements; Sense of place; Place attachment; Urban contexts

ICSBE 2023-250

A STUDY ON COMMUNITY HABITS AND LIFESTYLE CHOICES WITH SPECIAL REFERENCE TO NUGEGODA LOCALITY

K.A.S. Rathugamage[1*], D. De Silva [1], J. Wijesundara [1]

School of Architecture, Sri Lanka Institute of Information Technology.

**aakashrathugamage7@gmail.com, TP: +94778299481*

Abstract: With the rapid urbanization in recent years, there have been significant shifts in lifestyle preferences and habits in urban communities. This research aims to provide information that helps to understand the local lifestyle habits and preferences in Nugegoda to a greater extent. It intends to provide information that can be used as a framework when planning decisions. This study focuses on and addresses the variables that affect the decisions and behaviours of Nugegoda residents. It also comprehends and evaluates the accessibility, usefulness, and quality of the amenities and services they use. The impact of socioeconomic factors on these preferences will be examined in this study. Further, it compares disparities and inequalities. The research is conducted through a quantitative analysis of primary data. There are 2 main ways followed in collecting data. One is by conducting surveys, the other is by interviewing residents in Nugegoda. Age, income, occupation, and cultural background are just a few of the variables that the survey will collect data on to understand how lifestyle habits and preferences are influenced. The study also identifies the facilities and services that are most frequently used in Nugegoda and evaluate their value, usability, and availability. Different amenities and services including educational opportunities, healthcare centers, community and cultural events, and green areas are investigated in this research. Finally, the preferences and lifestyle choices of residents of other areas and Nugegoda residents will be compared. Overall, this study suggests uplifting the quality of life for Nugegoda residents and fusing the inequalities or disparities among them by identifying gaps in accessibility and availability of amenities and services.

Keywords: Lifestyle choices; community habits; Priorities in lifestyle; Locals' preferences

ICSBE 2023-256

MACHINE LEARNING APPROACH FOR MODELING MODE CHOICE DECISIONS OF SRI LANKAN TRAVELLERS

W.D Lakmini [1*], I.C.S Jayasena [1], W.R.S.S Dharmarathna[1], U. Jayasinghe[2]

[1]Department of Civil Engineering, University of Peradeniya, Sri Lanka.

[2]Department of Computer Engineering, University of Peradeniya, Sri Lanka

**Correspondence E-mail: e16201@eng.pdn.ac.lk, TP: +94716449199*

Abstract: Analysing travellers' mode choices is an important task to get an insight into transportation planning, policymaking, and understanding the future travel demands and travel mode choices. Travel mode choices are primarily estimated by using discrete choice models. Among them, Multinomial Logit model (MNL) can be indicated as the most widely used mode choice model. Machine Learning (ML) is an emerging approach that can also be used for modelling mode choices. In contrast to MNL models ML models do not make drastic assumptions about the data set. Therefore, ML approach has some advantages for modelling the mode choice over the traditional MNL approach. This study is set to look at a possible ML approach, specifically the Support Vector Machine (SVM) algorithm, for predicting travellers' mode choices using trip-specific, socioeconomic, and household data. Raw data was gathered by conducting an online and a face-to-face questionnaire. The study evaluates the performance of the SVM algorithm under different kernels and criteria, including prediction accuracy, precision, recall, and also F1 score which is used to measure the harmonic mean of precision and recall. The latter part of the study compares the MNL approach and the ML approach, where the former considers nine modes with travel time, cost, and distance as parameters estimated using utility maximization theory. The ML model is presented as an alternative solution for predicting mode choice, addressing the limitations of traditional models.

Keywords: Machine Learning; Multinomial Logit Model; Support Vector Machine; Travel Mode Choice; Transportation Planning

ICSBE 2023-269

URBAN GOVERNANCE AND POLICY FORMULATION IN URBAN SLUMS AND SHANTY DWELLERS IN SRI LANKA (SPECIAL REFERENCE TO THE 'HAVELOCK' SLUMS IN COLOMBO DISTRICT)

H.A.S.U. Geethanjalee[1*], D.M.Y. Abeywardhana[2]

[1]Department of Political Science, University of Peradeniya, Sri Lanka.

[2] Department of Sociology, University of Peradeniya, Sri Lanka.

**Correspondence E-mail: sgeethanjalee@arts.pdn.ac.lk , TP: +94711698934*

Abstract: The resettlement and management of slums and shanty dwellers has become a popular discourse which is influencing sustainable urban management around the world. Sri Lanka has implemented various public policies as urban governance approaches in this regard. After the 30 Years' War, numerous programs were implemented by ruling regimes focusing on the people of the capital city, Colombo. In this context, it is expected to study through this research the failure of the urban governance and public policy formulation process in the management and resettlement of slums and shanty dwellers. The objectives of the research are to describe the urban governance approaches related to slum and shanty construction and the resettlement process also to find out the relationship between the resettlement process and the policy-making process. In addition to finding out the new norms and changes in public policy and public administration in the resettlement of slum and shanty dwellers. The main research sample is based on 130 from 'Havelock' slums and shanty dwellers (18-70) of the age category. The primary data were collected through questionaries, interviews, participatory observations while secondary data were collected through academic journals, research articles and relevant reports. Maslow's theory, Neoliberalism theory, patron-client relationship and theory of space production were utilized for theoretical background. The SPSS software was used to analyse the quantitative data and the collected qualitative data were analysed by the thematic analysis method. The research findings explain that a patron-client relationship is maintained in the introduced public policies and urban governance process. This relationship is also connected with the bureaucracy. Moreover, some slums and shanty dwellers strongly express their opinion opposed to resettlement. The urban space is the social space for the dwellers as their identity, culture and sense of belonging are bounded by their location. In contrast, the policymakers view the urban space as an abstract sphere that can be used in economic development. It can be concluded that political relations and bureaucratic features are operating in the urban governance programs and public policy formulation process that are continuously implemented for the slum and shanty dwellers. This has excluded the underserved communities from their right to the city.

Keywords: Patron-Client Relationship; Poverty; Public Policy; Shanty Dwellers; Slums; Urban Governance

ICSBE 2023-292

ASSESSING THE IMPACT OF WETLAND CONVERSION TO UNREGULATED URBAN DEVELOPMENT ON FLOOD RISK: A GIS-BASED ANALYSIS OF THE MEDA ELA AND PINGA OYA CATCHMENTS IN KANDY DISTRICT

W.M.S.S. Dias [1*], D.M.L. Dissanayake [1]

[1]University of Peradeniya, Peradeniya, Sri Lanka.

**Correspondence E-mail: mihirdias@gmail.com, TP: +94779414936*

Abstract: Urban flooding is a significant challenge facing the city of Kandy, situated in the central highlands of Sri Lanka. This study focuses on assessing the impact of wetland conversion to unregulated urban development on flood risk in the Meda Ela and Pinga Oya catchments in the Kandy district, utilising the Geographic Information System (GIS). The main objectives of this research involve a comprehensive examination of temporal changes in land use and land cover (LULC), with a particular emphasis on the sealing of wetlands (paddy lands) and their implications for urban flooding. To achieve these objectives, the study employs secondary data, including land use data from the Survey Department of Sri Lanka spanning the years 1999 to 2020, elevation data from USGS, built-up area data from ESA world-cover, and historical flood events from different secondary sources. The research methodology encompasses, 1) reclassification analysis to identify wetlands, 2) zonal analysis to quantify wetland extents, 3) terrain analysis to spot low-lying areas near main streams, and 4) Multicriteria Decision Making (MCDM) to delineate a flood risk model using ArcGIS 10.8.2. The findings reveal a significant reduction in wetland areas and a corresponding expansion of built-up regions during the considered period in catchment scale and corridor scale. In the Meda Ela catchment, wetlands decreased from 44.66 hectares to 27.53 hectares, and built-up areas increased from 20.99 hectares to 196.62 hectares. Similarly, in the Pinga Oya catchment wetlands decreased from 1995.23 hectares to 1642.57 hectares, with the expansion of built-up areas from 2.25 hectares to 15.63 hectares. Correspondingly, the temporal growth of wetlands sealing led to a rise in flood events in both catchments. MCDM-based flood risk model indicated specific areas, like Kandy City to Suduhumpola reach in the Meda Ela and Akurana to Ambathenna in the Pinga Oya catchments, which are highly vulnerable to flooding due to their basin characteristics. Consequently, this study highlights the need for sustainable flood mitigation strategies by preserving existing wetlands and practicing resilience in systematic urban development.

Keywords: Urban floods; Wetlands; Geographic Information System (GIS); Meda Ela; Pinga Oya

ICSBE 2023-280

A COMPARATIVE LIFE CYCLE ASSESSMENT OF E-THEIS AND BOUND THESIS USING THE GATE-TO-GATE APPROACH

Y Suwarkka[1*], K Kumareswaran[1], M Atapattu [2]

[1]Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka

[2]Department of Animal Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka

**Correspondence E-mail: 2017ag4660@agristu.ruh.ac.lk, TP: +94761729811*

Abstract: It has repeatedly been suggested that dematerialization via ICT (Information and Communication Technology) could assist in advancing environmental sustainability. This might be a paradigm shift on dissertations submitted by university students by employing e-thesis perspective, since it shares several characteristics in common with printed material and exhibits remarkably higher environmental performance. The primary objectives of this study were to evaluate the environmental advantages of submitting an e-thesis as an alternative to a bound-thesis; identifying potential hotspots responsible for the highest environmental burdens during the various stages of the life cycle of a bound-thesis and to offer potential solutions for mitigation. OpenLCA 1.11 was employed to execute a screening LCA comparing a typical bound thesis with its softcopy submitted as e-thesis representing Faculty of Agriculture, University of Ruhuna, Sri Lanka by utilizing U.S. EPA life-cycle inventory data that are regarded to be with the average quality applicable worldwide. The findings indicated that, paper and cover import stage of the bound-thesis product system was the life cycle phase bearing the most to the environmental effect of the systems evaluated, followed by the paper production in terms of global warming potential of 4830.3 ton CO2 eq and the marine eutrophication with 29041.5 kg N eq respectively. From an environmental standpoint, e-thesis is superior to bound-thesis across the majority of impact classes and situations. Since stratospheric ozone depletion is the sole impact category where e-theses perform poorly, electricity generation must concentrate on renewable resources like biorefineries, e-reading platforms needs to be used frequently, the lifespan of the device shall be extended to the extent possible, and when not being in use any longer, the device must be securely disposed to enable material recycling. Additionally, the manufacture of the e-reader needs to be energy-efficient and attempt to reduce the use of rare hazardous materials.

Keywords: Bound-thesis; Dematerialization; Environmental Impacts; E-thesis; Life Cycle Assessment (LCA)

ICSBE 2023-290

ENHANCING URBAN FLOOD RESILIENCE THROUGH PERVIOUS CONCRETE: INNOVATIVE SOLUTIONS FOR SUSTAINABLE URBAN LANDSCAPING

M.N.M SHAHMY[1*], D.D DIAS[2] and U.B.S FERNANDO[1]

[1]Department of Civil Engineering and Build Environment,
Liverpool John Moores University, UK
[2]Department of Civil Engineering, University of Peradeniya, Sri Lanka
**Correspondence E-mail: mhdsharm@gmail.com, TP: +94775235572*

Abstract: Global urbanization brings challenges like increased impervious surfaces and flooding vulnerability. Pervious concrete, a sustainable material, offers a solution by mitigating flooding and enhancing urban landscapes. This study explores a suitable concrete mix design for pervious concrete in enhancing the urban flood resilience by managing storm-water. This involves an in-depth investigation of the properties and behaviour of pervious concrete made with varying proportions of fine aggregate-to-coarse aggregates percentages accompanied by different fly ash to cement ratio and waste fibers, and varying W/C ratios, focusing on its permeability, compressive and splitting tensile strength, and water retention capabilities. It aimed to enhance the strength of the pervious concrete while minimizing the additional fines percentage through the incorporation of fibres. Laboratory experiments and field trials are conducted to assess the material's performance under various rainfall intensities. The study identifies the optimal mix designs of pervious concrete of 30 Mpa to be 0% fines, 0.3% fly ash and 0.27% water-to-cement ratio effectively promotes infiltration and percolation of storm-water with 20% of voids, reducing surface runoff and mitigating the risk of flooding. When reducing the fine content; the in-filtration rate was increased. The material exhibits sufficient 31.6 MPa compressive strength and 2.9 MPa splitting tensile strength for typical urban applications while allowing water to pass through 0.95 cm/s, facilitating groundwater recharge and enhancing overall water management. Infiltration rate is increased by 57% than conventional concrete. It reveals, with the increase percentage of fly ash to cement ratio actively enhance the permeability of the concrete up to 75% comparative to conventional type, while waste fibers adding shows no effect to the permeability but to increase of the strength. This study leads to potential savings in the design and installation of traditional drainage infrastructure with adoption of pervious concrete as an integral part of urban design in pavement construction.

Keywords: Pervious concrete; Flood mitigation; Sustainable urban landscaping; Storm water management; Groundwater recharge

ICSBE 2023-298

URBAN FOREST ECOSYSTEM SERVICES AND MANAGEMENT: A CASE STUDY OF THE THREE MAIN FOREST PATCHES WITHIN KANDY CITY, SRI LANKA

D.M.L. Dissanayake[1], G.K.C.R. Kapuge[1]

[1]Department of Geography, University of Peradeniya, Sri Lanka

**Correspondence E-mail: chirasthirashmila@gmail.com TP: +9476 641 2168*

Abstract: Urbanization, driven by rapid population growth and urban sprawl, has transformed landscapes worldwide, impacting the environment in profound ways. In this context, urban forests have emerged as crucial components of urban ecosystems, offering a multitude of ecosystem services. the objective of this study is to identify the current status of ecosystem services and the challenges faced by three main forest patches: Hanthana, Dunumadalawa, and Udawattakele within Kandy City, in Sri Lanka in the last twenty years. Relevant data that were collected through field surveys, observations, interviews, satellite images, etc. were analysed using both qualitative and quantitative methods. The urban forest cover in Kandy had decreased from 64 to 48.9% during this study period. Urbanization is a significant factor in the degradation of urban forests while deforestation, invasive species, and parasites challenge ecosystem services in urban forests. The urban land cover within Hanthana in particular has increased from 1.7 to 13.1% between 2010 and 2016. Despite this decline, these urban forest patches play a crucial role in maintaining ecological and social balance, regulating the local climate, improving air quality, and offering recreational spaces that promote physical and mental well-being, social cohesion, and cultural value. Urban forests collectively support biodiversity, bolstering resilience against climate change impacts, while acting as key water catchment areas, affecting the city's water supply. Regardless of the varying protection status of each forest patch, they all face similar challenges in preserving the forest cover within the said boundaries. The financial strain on local governments, political influence, resource limitations, and lack of expertise for effective management hinder the management potential of urban forests. Proactive management strategies are crucial to balance these challenges, ensuring the preservation of ecosystem services and biodiversity. Integrating urban forest management into development agendas is vital in enhancing ecological integrity for a more sustainable city.

Keywords: Kandy City; Urban Forest; Ecosystem services; Encroachment; Urbanization

ICSBE 2023-299

GREEN IMPRESSIONS: UNDERSTANDING URBAN VEGETATION PERCEPTIONS IN UNESCO HERITAGE CITY KANDY

D.M.L. Dissanayake [1], D.R.P. Godamunna [1*]

[1]University of Peradeniya, 20400, Sri Lanka

**Correspondence E-mail: paviigodamunna@gmail.com, TP: +94711461400*

Abstract: Urban areas play a crucial role in addressing sustainability concerns due to their significant ecological impact. Sri Lanka's "National Physical Planning Policy and the Plan-2017-2050" (NPPPP-2017-2050) emphasises the importance of promoting a green built environment in urban development. In 2018, Kandy, a UNESCO World Heritage City celebrated for its historical, cultural, and environmental value, launched a street corridor tree-planting initiative. This study explores the nuanced perceptions of urban street corridor vegetation within this distinctive context. Nestled amidst hills on a plateau, Kandy faces the challenges of air pollution circulating within the city. To examine public opinions on urban vegetation, a comprehensive survey targeted two respondent groups: city residents and visitors, both local and foreign. Using observation and field surveys, this study revealed insights into perceptions and attitudes towards Kandy's street corridor vegetation. It identified 34 short and long vegetation belts in the city's grid areas. Foreign visitors were relatively scarce, while a significant proportion of respondents declared themselves as regular or occasional visitors, underscoring the city's enduring appeal. Regarding urban vegetation, 45.61% of respondents had a positive view and somewhat positive view, emphasising its aesthetic appeal and benefits like fresh air and shelter. 5.26% were neutral, and 3.51% expressed a negative impression. Concerns encompassed potential harm to ancient monuments, damage to internal drainage and electrical systems, restricted pedestrian pathways, increased bird populations impacting historic buildings, and pavement damage caused by tree roots. The study uncovered diverse perspectives on enhancing urban greenery, particularly focusing on aesthetics, environment, and culture. Participants provided a range of ideas and recommendations for enhancing urban vegetation in specific street corridors. This research provides valuable insights for urban planners and policymakers interested in preserving Kandy's heritage and environment. Additional research and initiatives are needed to align urban vegetation development with the preferences of residents and visitors, promoting sustainability and heritage preservation.

Keywords: Urban Vegetation; Perceptions; UNESCO Heritage City; Sustainability; Kandy

ICSBE 2023-301

ASSESSING THE LEVEL OF CONNECTIVITY OF THE RIVERSCAPE STRUCTURE: A SPATIAL GRAPH-BASED APPROACH

GUKM Garusinghe[1*], HMM Herath [1]

[1]University of Moratuwa, Colombo Sri Lanka.

**Correspondence E-mail: ukmgarusinghe@gmail.com, +94766723559*

Abstract: In recent times, there has been a growing focus on using graph theory approaches to plan and maintain terrestrial landscapes due to their ability to predict habitat connectivity. This research explored how fundamental graph theory concepts can be employed to measure riverscape connectedness and understand its significance. It also illustrates how a spatial graph-based approach can be instrumental in the more efficient conservation of riverine systems. This study investigates the topological importance of segments in preserving riverscape connectivity within the Kelani River basin. It employs betweenness centrality, a prominent network measure, to analyze a real stream network. Subsequently, the segments are prioritized for preservation by utilizing the Integral Index of Connectivity within the riverscape's graph model. The paper then explores the weighted values of Betweenness Centrality and Integral Index of Connectivity to identify the highest priority hotspot as the final outcome. By evaluating the conservation value of stream segments and employing various assessment methods, we assess the significance of each segment within the Kelani River Basin.

Keywords: Conservation; Graph Theory; Land Use Planning; Riverscape Connectivity; River Stream Fragmentation; Kelani River.

ICSBE 2023-340

INFLUENCE OF URBAN PARKS ON URBAN THERMAL ENVIRONMENT – A CASE STUDY: INTERMEDIATE ZONE & ARID ZONE IN SRI LANKA

W.G.K.D.Jayalath[1*], T.A.N.T.Perera[2], G.Y.Jayasinghe[2]

[1]Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Matara, 81100, Sri Lanka.

[2]Department of Export Agriculture, Faculty of Animal Science & Export Agriculture, Uva Wellassa University , Passara Road , Badulla , 90540,Sri Lanka

**Correspondence E-mai:Jayalath4902@ags.ruh.ac.lk, TP: +9471 9383852*

Abstract: Urban parks are a type of green infrastructures that can be introduced as a significant solution to replace the declined greenery in urban environment and they have emerged potential strategies to mitigate adverse effects urban thermal conditions. Evaluating the performance of urban parks is mandatory at tropical conditions, as it indicates the research gap. In this study, thermal performance, Relative Humidity (RH) & CO_2 concentration was quantified for a selected park in intermediate zone, Sri Lanka. An in-situ experimental study was considered air temperature, RH & CO_2 & simulation study was conducted for arid zone. The simulation study examined impact for the thermal environment on urban parks by modeling a designated site with ENVI-met 5.1.1.0 microclimate software. The model was validated by observed values & simulated values. R- Squared (R^2) value for temperature was 0.95. The model was used to generate microclimate data for two scenarios as the existing condition and after installation of an urban park in the selected area in Arid zone Sri Lanka. An occupant satisfaction survey was executed to assess the performance of urban park & awareness on Urban Heat Island effect for the Intermediate zone. The study revealed that the maximum temperature reduction of selected urban park was 4.72˚C. Recorded RH values mostly lower than the city & CO_2 levels showed fluctuations with the time. The questionnaire survey revealed that 78% people were highly satisfied with the urban park. The simulation study showed 2.47 ˚C maximum temperature reduction that reveals the value of urban parks in an urban thermal environment. According to the study, urban parks can be identified as a very effective green infrastructure for reducing the urban heat while ensuring the human wellbeing. Thus the influence of the urban parks for the tropical conditions should be further studied and the knowledge should be use for the design of sustainable cities.

Key words: CO_2 concentration; ENVI-met; Occupant satisfaction; Relative Humidity; Urban parks; Urban thermal comfort

GEOTECHNICAL ENGINEERING

ICSBE 2023-6

THE DRIEST END OF THE SOIL WATER CHARACTERISTICS CURVE (SWCC) WAS DEVELOPED FOR DIFFERENT SOIL DEPTHS USING WP4C

K.K.A, Shanika[1, 2], Y.N.S. Wijewardana[1]*, H.M.S.K, Herath[3], L.W. Galagedara[4]

[1]Department of Engineering Technology,
Uva Wellassa University of Sri Lanka, Badulla, Sri Lanka
[2]Postgraduate Student, Uva Wellassa University
[3]Department of Export Agriculture, Uva Wellassa University of Sri Lanka, Badulla, Sri Lanka
[4]School of Science and the Environment, Memorial University of Newfoundland,
Corner Brook, NL, Canada
**Correspondence E-mail: senani@uwu.ac.lk, TP: +94 706970266*

Abstract: Hydraulic properties of soil and their applications are important for solving many water management issues. This paper presents the study of hydraulic properties at five selected sites in *Haputale (HP), Haldummulla (HD), Meegahakiula (MK), Haliela (HE),* and *Uva Wellassa University (UWU)* in *Badulla* district, Sri Lanka. The objectives of this study were to i) develop the driest end of soil-water characteristic curves (SWCCs) for different soils and depths using WP4C, and ii) predict the driest end of SWCCs using the van Genuchten (1980) model. Field and laboratory investigations were conducted at selected locations, encompassing 14 soil depths, and utilizing both disturbed and undisturbed soil samples. The topsoil (0.00 – 0.05 m), was collected from *HP, HD, MK,* and *HE* locations, and ten different soil depths at 0.05 m intervals from 0.0 to 1.0 m were collected from the prepared soil profile at the UWU. Selected soils were sandy clay loam, clay loam, and clay having different bulk densities (ρ_b). Sieved soils from 2 mm mesh were used to measure soil pF using the WP4C (METER Group, *Inc*, USA) for the respective soil moisture content. Subsequently, the observed data were fitted using the van Genuchten (1980) model and its model and corresponding model parameters, α, n, m (α – air entry value, n – water entry value, $m = (1-1/n)$ value related to pore size distribution) were compiled for all soil types and depths. From the comparison and statistical analyses, the experimental and predicted SWCCs show that the predicted data better fit ($R^2 < 0.87$) with measured data for selected sampling sites. Further, *HD* topsoil shows the highest K_{unsat} value, which has the highest ρ_b value (1.5 g cm^{-3}), the highest sand fraction (66.0%), and the lowest silt fraction (9.0%) among the tested soils.

Keywords: WP4C Potential Meter; Dry soil; Soil-water characteristic curve

ICSBE 2023-13

INVESTIGATION OF GEOTECHNICAL PROPERTIES OF EXPANSIVE SOIL STABILIZED WITH FLY ASH AND QUARRY DUST

T.B.C.H. Dissanayake [1*], D. de S. Udakara [1]

[1]*Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Peradeniya, Sri Lanka.*

**Correspondence E-mail: charith035@gmail.com, TP: +9471-7532849*

Abstract: Expansive soils are classified as problematic soils which causes distresses to lightly loaded structures due to changes in volume with moisture content. Therefore, it is crucial for both design engineers and geotechnical engineers to identify such ground and modify it in order to alter the geotechnical engineering properties and adjust the designs accordingly. In this research, series of experimental testing such as Standard Proctor Compaction Test, Atterberg Limit Test, Swell Pressure Test and Unconfined Compression Test were conducted to examine the geotechnical properties of expansive soil stabilized with different percentages of fly ash (0%, 5%, 10%, 15%) and quarry dust (0%, 10%, 20%, 30%). Experimental results indicated that the maximum dry density values of stabilized soils increased with increasing quarry dust content for a constant fly ash content. But optimum moisture contents showed a decreasing trend. However, variation tends of optimum moisture contents and maximum dry density values turned reverse with fly ash contents for a given quarry dust percentages. In addition, a notable decrease was observed, in the plasticity index values and swell pressure values of stabilized soil when increasing both fly ash and quarry dust contents. Moreover, test results revealed that the unconfined compressive strength (UCS) values of stabilized soil increased gradually with increasing fly ash and quarry dust content. But the rate of increase was reduced with higher percentages of additives. The 7 days to 28 days, maximum UCS value was observed with a 10% fly ash content and a 30% quarry dust content. In addition, an increase in UCS values was noticed with curing periods of 7 days to 28 days. On the whole, fly ash and quarry dust can be successfully utilized in the soil stabilization process to improve the geotechnical engineering properties of expansive soil.

Keywords: Expansive soil; Fly ash; Quarry Dust; Swell Pressure; Unconfined Compressive Strength.

ICSBE 2023-16

STRENGTH, SWELL AND COST BASED MIX OPTIMIZATION OF CEMENT AND FLY ASH TREATED EXPANSIVE SOILS

A.M.S.N. Abeysinghe[1*], L.C. Kurukulasuriya[1], M.C.M. Nasvi[1]

[1]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya

**Correspondence E-mail: snabey96@gmail.com, TP: +94702256021*

Abstract: Expansive soils pose significant challenges in construction projects due to their high susceptibility to volumetric changes caused by moisture fluctuations. Chemical stabilization of expansive soil has been successfully practiced for many years now to enhance the strength and swell characteristics of expansive soils, and cement and fly ash (FA) have been successfully used as stabilizing agents. However, very limited studies have been conducted focusing on the mix optimization of a given expansive soil using cement and FA by considering the strength, swell and cost. Therefore, the aim of this research is to perform a mix optimization of cement and FA stabilized expansive soil in terms of strength, swell and cost analysis. Expansive soil samples were stabilized with 2-12% cement and 5-30% FA, and testing including index properties, unconfined compressive strength (UCS) and swell pressure were conducted. In addition, ranking of the mixes was done by performing a utility analysis by employing Multi-Attribute Utility Theory (MAUT) incorporating strength, swell pressure and cost/UCS as the key performance indicators. The findings revealed that UCS of the cement stabilized samples increases with the stabilizer content, whereas 15% FA was found to be the optimum FA content for high UCS for FA stabilized samples. The UCS values of all the stabilized samples complied with the Austroads (Australia) and Institute for Construction Training and Development (ICTAD) (Sri Lanka) guidelines. The swell pressure values of cement stabilized samples and FA stabilized samples were reduced by 11.6% - 35.9% and 45.0% - 65.6% respectively depending on the binder content. The findings of the utility analysis revealed that all the FA stabilized samples outperformed cement stabilized samples, and 15% FA stabilized mix is the most reliable mix whereas 4% cement stabilized mix was found to be the least reliable mix in terms of strength, swell and cost.

Keywords: Expansive soil; Soil stabilization; Unconfined compressive strength; Swell pressure, Cost analysis

ICSBE 2023-42

ASSESSMENT OF SHEAR STRENGTH PROPERTIES OF DREDGED SAND

P.L. Punchihewa[1*], R.J.K.B.C. Ranathunga[1], A.M.R.G. Athapaththu[1]

[1]Department of Civil Engineering, University of Peradeniya, Sri Lanka.

** Correspondence E-mail: Lasith97punchihewa@gmail.com, TP: +94766256913*

Abstract: Land reclamation using marine dredged sand has been a more popular method to provide land to meet the requirement of increment of population and expanding economic development over several decades. Therefore there have been several geotechnical issues in line with the reclaimed land areas. The loose sand can lead to a high risk of liquefaction due to seismic actions and other vibrations. Unsuitable filling methods can also lead to unexpected short-term and long-term settlements with the construction of different structures having various load applications. To eliminate such failures, the sand has to be densified up to the acceptable level of compaction over the specified depths. The relative compaction can be assessed through the examination of the geotechnical properties of marine dredged sand. Due to the difficulty of extraction of undisturbed samples in cohesionless soils, CPT-based empirical correlations are used to evaluate the relative density and effective angle of friction. In general, cohesion and friction angle represents the shear strength parameters of soils and the linear Mohr-Coulomb envelope is been widely used to explain the theoretical concept. However, due to the effect of factors such as confining pressure, relative density, mineralogy, particle crushing, particle size distribution, etc., the Mohr-Coulomb envelope deviates from the linear behavior. In this study, the variation of shear strength parameters of dredged sand with relative density was evaluated and non-linear stress variation with the increase of normal stress was assessed using a series of direct shear tests. Tests were carried out for relative densities of 90%, 95% and 97% with normal stresses varying from 20 kPa to 800 kPa. Based on the results and using previous studies on dredged sand, a virtual direct shear test model was developed using the Discrete Element Method (DEM) reducing the experimental time increasing the efficiency.

Keywords: Land reclamation; Dredged sand; Relative density; Shear strength; Direct shear test; DEM

ICSBE 2023-44

STABILITY ANALYSIS OF ROAD EMBANKMENT CONSTRUCTED BY TREATING MARGINAL SOILS WITH GEOPOLYMER BASED STABILIZERS

S. Tharshsany[1], S. Shagiththiya [1], M.C.M Nasvi [1*], J. Sangeetha[1]

[1]Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Peradeniya, 20400, Sri Lanka.

**Correspondence E-mail: Nasvimcm@eng.pdn.ac,lk, TP: +947812393516*

Abstract: Road embankment materials meeting the required standard are not readily available nearby most of the time and treating these marginal road embankment materials with a suitable admixture can enhance geotechnical properties. Alkali activated geopolymers prepared with fly ash (FA) and rice husk ash (RHA) have attracted the attention as a novel binder in the recent past due to their excellent performance. This research aims to analyze the stability of the embankment constructed using marginal embankment materials treated with FA and RHA based geopolymers using experimental and numerical works. Under experimental work, two geopolymer stabilized soil mixes were prepared follows: (1) FA based geopolymer stabilized soil (FA-GP-SS) with a mix composition of geopolymer/soil = 0.3, 8M NaOH, FA/Alkali activators = 2 and Na2SiO3/NaOH = 2.5, and (2) FA-RHA based geopolymer stabilized soil (FA-RHA-GP-SS) with a mix composition of geopolymer/soil = 0.3, 8M NaOH, FA:RHA= 40:60 and Na2SiO3/NaOH = 2.5. A series of experiments were conducted to obtain the geotechnical properties of the raw and stabilized soils. Under numerical study, PLAXIS 2D and GeoStudio software were used to analyze the slope stability of the embankment constructed with FA-GP-SS and FA-RHA-GP-SS. The height of the embankment and slope angle varied from 4-6 m and 300 – 750 respectively and the factor of safety (FOS) values obtained from both software were compared. Based on findings, FOS values obtained from both software were comparable. The FOS values were higher for the embankment constructed using two stabilized mixes (FA-GP-SS and FA-RHA-GP-SS) compared to those made of raw soil. FA-GP-SS outperforms FA-RHA-GP-SS due to higher reactivity and pozzolanic activity of FA compared to RHA. On the whole, geopolymer based stabilizers can be used to enhance the marginal soils for road embankment construction.

Keywords: Embankment; Fly ash; Rice husk ash; Stabilized soil

ICSBE 2023-112

PREDICTION OF COLLAPSE POTENTIAL OF SOILS USING ARTIFICIAL NEURAL NETWORK

A.K.B.J. Aththanagoda[1*], L.C. Kurukulasuriya[1]

[1]Department of Civil Engineering, University of Peradeniya, Sri Lanka

**Correspondence E-mail: bhagyajayaba95@eng.pdn.ac.lk, TP: +94717006703*

Abstract: Collapsible soils refer to a specific type of unsaturated soil that exhibits a notable decrease in volume when it becomes saturated. This phenomenon of volume reduction can occur with or without the application of an additional load. Collapsible soils are one of the prominent types of problematic soils and can be found in many parts of the world. This volume change of collapsible soil might cause severe damage to structures founded on it. When the structures are built in a collapse-prone area, it is essential to evaluate the collapse potential of the soil to minimize the cost of rehabilitation of damages associated with the collapse settlement. In this study, Artificial Neural Network (ANN) is developed in Python programming language using 327 data sets available from the literature to obtain more reliable functional relationships between various soil parameters and the collapse potential of soil. ANN model is trained and tested using oedometer test results available in the literature. Multiple relationships are established to facilitate the computation of collapse potential using a selected number of soil parameters including a relationship with enhanced accuracy when greater number of parameters is available.

Keywords: Problematic Soils; Artificial Neural Network; Collapse Potential; Python

ICSBE 2023-127

COMPARISON OF IN-SITU STATE OF A TAILINGS DEPOSIT WITH RECONSTITUTED LABORATORY SPECIMEN STATES

PGN Nayanthara[1*], C Gallage [1], SSSD Biyanvilage [2], J Rajapakse [1], T Rowles [3], E Tuplin [4]

[1]Queensland University of Technology, Brisbane, Australia.

[2]Advisian Group Pty. Ltd., Brisbane, Australia.

[3] Knight Piésold Pty. Ltd., Brisbane, Australia.

[4]BHP, Australia.

**Correspondence E-mail: nishadinayanthara.pahalage@hdr.qut.edu.au, TP: +61450100368*

Abstract: Since a series of significant failures of tailings deposits has occurred, importance of accurately characterising the tailings has taken a great deal of attention over the past decade. The initial steps of tailings characterisation involve using cone penetration testing (CPT) to estimate the in-situ state and loosely reconstituted laboratory specimens to infer the critical state line (CSL). However, the preparation of laboratory specimens to mimic the in-situ state in terms of density and fabric is considered challenging. Despite such concerns, the use of moist tamping (MT) currently dominates as the industry practice for the identification of CSL, whereas employing non-segregating slurries is also not rare. In this study, piezocone (CPTu) data and tube samples collected next to CPTu locations within the saturated regions of a tailings deposit were utilised. The in-situ state was estimated using two independent methods: calculating in-situ void ratios using the gravimetric water content (GWC) determined from tube samples and using CPTu screening methods where void ratios are calculated based on the state parameter (ψ) values obtained for the target depth range. Simultaneously, a series of triaxial tests were conducted using MT and SD specimens to obtain their consolidated states at varying stress levels and to infer the CSL. Results indicated that SD tests achieved slightly denser states than that obtained from MT specimens, but interestingly not states well below the CSL as commonly cited in previous studies. The CPTu inferred ψ span over a wide range and hence the in-situ states are either looser than or in agreement with the densities obtained from MT tests. The GWC measurements based in-situ states overlap with the looser end of the CPTu inferred range. This raises the question as to which degree the homogeneously prepared denser laboratory specimens has the capability to mimic the behaviour of loosely deposited tailings in a tailings storage facility.

Keywords: cone penetration test; critical state line; in-situ state; mine tailings; reconstituted samples

ICSBE 2023-130

USE OF FIELD MONITORING DATA AND THE FINITE ELEMENT ANALYSIS IN THE OPTIMIZATION OF DEEP EXCAVATION SUPPORT SYSTEMS: A CASE STUDY

V.S.S.D. Silva [1*], L.I.N. de Silva [1]

[1] Department of Civil Engineering, University of Moratuwa, Sri Lanka.

**Correspondence E-mail: sachindeelakasilva@gmail.com, TP: +94716060944*

Abstract: This study proposes a method to optimize the design of retaining walls during deep excavations using measured field monitoring data and a two-dimensional finite element analysis. Many studies indicate that the unloading-reloading modulus (E_{ur}) of soil should be used in the finite element analysis of deep excavations, and the elastic modulus (E_{50}) of the soil can be increased by several times to obtain the unloading-reloading modulus (E_{ur}) of the soil. When comparing field deformations with those obtained from finite element analysis, it was found that E_{50} can be increased between 2 and 4 times to obtain the E_{ur} value to be used in the FE model. The numerical model was validated using the measured deformations of a retaining wall at various excavation depths. In addition, the prop forces obtained from the numerical model were compared with those obtained from different analytical methods commonly used to estimate prop forces on multi-propped retaining structures. Furthermore, the lateral pressure distribution along the retaining wall obtained from the numerical model was compared with the empirical methods used to calculate the prop forces to verify the results. The bending moment envelope of the retaining wall obtained from the numerical analysis was compared with the bending moment diagrams obtained using different analytical methods. The reduction in maximum bending of the wall was analyzed by assigning different stiffness values for soil in the numerical model. The study highlights that the maximum bending moment that acts on the retaining wall can be reduced between 20% and 40% through the optimization of the retaining wall design.

Keywords: Deep Excavation; Finite Element Analysis; Elastic Modulus; Back Analysis; Apparent Pressure Diagrams

ICSBE 2023-19

ANALYSIS OF THE SHEAR BEHAVIOR OF STABILIZED SOIL-CONCRETE INTERFACE IN GEOTECHNICAL STRUCTURES

W.A.W. Wijesingha[1*], K.H.S.M. Sampath [1]

[1]Department of Civil Engineering, University of Moratuwa, Sri Lanka

**Correspondence E-mail: sampathkh@uom.lk, TP: +94769915794*

Abstract: Quarry dust (QD) is a waste material often used for soil stabilization to improve the engineering properties of weak soil, and understanding the behaviour of the interface between the QD-stabilized soil and concrete structures has a significant role when considering the performance of geotechnical structures. Assessing the respective behaviour of the interface under various mix proportions of QD and the existing soil is important since the interface properties of stabilized soil mainly vary with the mix proportion. This research investigates the influence of different mix proportions of QD and Clayey-Sand (SC) on the interface shear behaviour by laboratory experiments with modified direct shear tests. The first phase of the research demonstrates that QD provides effective soil stabilization since the Plasticity Index is decreased by 46.8%, Maximum Dry Density and Shear Strength are increased by 11.26% and 74.57%, respectively under 200 kN/m^2 of normal stress, when the QD percentage in the stabilized soil is increased from 0% to 20%. In the second phase, the accuracy of recommended co-relations between interface shear strength properties and soil shear strength properties provided in existing design codes has been assessed, particularly focusing on the QD-based stabilized SC. The results showed that the Interface Friction Angle Reduction Factor, which is recommended in design guidelines overestimates, and in contrast, the Cohesion Reduction Factor underestimates the interface shear reduction of stabilized SC with QD. Hence, it is concluded that the interface shear behaviour highly varies with the interface soil properties and the surface roughness of the structure; as such, adopting a common interface reduction factor for both friction angle and cohesion is not always accurate. It is recommended that a design optimization should be performed by carrying out appropriate interface shear strength tests, especially when the existing soil is stabilized with an additive like QD.

Keywords: Shear Strength; Quarry Dust; Interface; Reduction Factor

ICSBE 2023-255

EFFECT OF GRID UNDER SLEEPER PAD ON SHEAR RESISTANCE AT SLEEPER-BALLAST INTERFACE

H. G. S. Mayuranga*, S. K. Navaratnarajah, C. S. Bandara and J. A. S. C. Jayasinghe

Department of Civil Engineering, Faculty of Engineering,University of Peradeniya, Peradeniya, Sri Lanka.

**Correspondence E-mail: sushanm@eng.pdn.ac.lk, TP: +94714960369*

Abstract: The shear resistance at the sleeper-ballast interface of ballasted rail tracks is crucial in maintaining the stability of the track superstructure under repetitive train loading. The application of Under Sleeper Pads (USPs) in ballasted tracks by attaching them underneath the concrete sleepers is popular for the purpose of reducing ballast degradation and improving track performance. Additionally, USPs contribute to improving the shear resistance at the sleeper-ballast interface compared to traditional concrete sleepers. Nevertheless, further improving the shear resistance at the sleeper-ballast interface is imperative when the rail tracks are subjected to larger axle loads under higher frequency due to the presence of faster and heavier trains. Consequently, the novel Grid Under Sleeper Pad (GridUSP) is proposed in this study to further enhance the shear resistance at the sleeper-ballast interface. Compared to traditional USPs, the GridUSP facilitates ballast particles to interlock at the sleeper-ballast interface and thereby improves shear resistance. This paper explores the effectiveness of GridUSPs in improving shear resistance at the sleeper-ballast interface through a series of large-scale direct shear tests and a numerical investigation using the Discrete Element Method (DEM). The direct shear tests were conducted under 60 kPa normal stress, considering different sleeper-ballast interfaces such as Ballast-Ballast, Ballast-Concrete, Ballast-USP, and Ballast-GridUSP. For this purpose, USPs and two types of GridUSPs manufactured using recycled material were employed. Numerical models of each interface were developed to evaluate shear behaviour under different normal stresses. Based on the numerical results, non-linear Mohr-Coulomb failure envelopes were developed for each interface, and apparent peak friction angle values were determined. The results revealed that the GridUSP with 30 mm diameter apertures and a 60 mm staggered pitch provides 34% and 158% improvements in peak shear stress at the sleeper-ballast interface compared to the conventional USP and concrete sleeper, respectively.

Keywords: Ballast, DEM, GridUSP, Large-scale direct shear test, Track stability

ICSBE 2023-321

INVESTIGATION OF FOUNDATION PROTECTION MORTAR LAYER WITH ABILITY TO WITHSTAND THE BEHAVIOR OF FINE GRAIN SOIL

J.A.S.M Jayasinghe[1*], U.B.S Fernando[1]

[1]Department of Civil Engineering & Built Environment, Liverpool John moores University, U.K

**Correspondence E-mail: sachithmadhushan99@gmail.com: J.A Jayasinghe1@2020.ljmu.ac.uk: +94-717027428*

Abstract: The Aim of this research was to create a foundation protection mortar layer that can protect the foundation from swelling, shrinking & high water level Presence in soil impact on foundation, occurs from fine grain soil's behavior. Researcher needed to create this layer as can survive itself at wet season swelling impact on foundation and in raining season's high water level of soil & dry season drying shrinkage on foundation protection layer. Also, this study wanted to create this layer by using activated carbon's moisture absorbing ability and mechanical strength. Adding activated carbon to cement + sand + water mixture with exact corrected ratio researcher wanted to prove this phenomenon by using 4 laboratory tests. They are cube test (IS 4031), speedy moisture test, water absorption test (ASTM C140), permeability check test. After conducting those 4 laboratory test researcher able came up with expected successful results. When activated carbon embedded with cement, sand, water with some ratio it increased compressibility strength and air moisture absorbing ability. Also, able to reduce its water absorption ability and permeability because researcher find out a method to reduce the foundation protection layers porosity. Researcher able to conclude all the 5 objectives and provide recommendation about how to apply this treatment effectively step by step under the research limits and recommendations. At the end researcher included research limits and next steps of this research project for future generation to follow. What researcher tried to create is, give a foundation protection treatment method that can cover all the Damage can occur to foundation from fine grain soil behavior by Increasing its Compressibility Strength, Reducing Water absorptivity, increasing its air moisture absorptivity & reducing water permeability by using activated carbon. Also, this method will be easier to apply and only require very less amount of budget, time & man power.

Keywords: Fine grain soil; Activated carbon; Swelling; Shrinking; Foundation; Mortar layer

ICSBE 2023-346

REVIEW OF RELIABILITY EVALUATION OF CROSS-HOLE SONIC LOGGING FOR BORED PILE INTEGRITY

Y.A. Naotunna[1*], N.H. Priyankara[2], D.M.K.N. Seneviratna[3]

[1]Abdulla Ahamd Abriki Est for Contracting, Saudi Arabia.

[2]Department of Civil and Environmental Engineering, Faculty of Engineering, University of Ruhuna

[3]Department of Interdisciplinary Studies, Faculty of Engineering, University of Ruhuna

** Correspondence E-mail: aklanka06@gmail.com, TP:+94777100830, +966507698314*

Abstract: As such, in-situ testing is required for quality control of bored piles during construction. Defects are common in bored piles such as necking, cracking, void, bulging, poor quality material, soft toe and soil inclusion. Due to ease of use, Cross-hole Sonic Logging (CSL) has become a common and best available in-situ method to evaluate the integrity of bored piles. Defects within the bored piles may not always be detected during CSL test. It is impractical to inspect 100% of the bored on the available limited test data. As such, in this research study, effect of number of access tubes on the prediction of reliability of CSL test was presented. Reliability of the CSL method was evaluated by reviewing the methods proposed by different researchers based on experimental data and probabilistic approaches. In the conventional approach, the number of access tubes are decided based on the pile diameter in which one access tube is used for each 0.25-0.3m diameter of bored pile with minimum of 3tubes. In the probabilistic approach, inspection probability defined as a product of encountered probability and detection probability. Based on the analysis, the optimum number of access tubes required for CSL test for a particular pile diameter were defined.

Keywords: Bored Piles; CSL Test; Defect Flows; Probabilistic Approach; Reliability

ICSBE 2023-360

REVIEW OF LOAD SHARING MECHANISM OF PILED- RAFT FOUNDATION

D.A.P.Prasad[1*], N.H.Priyankara [2]

[1]National Watetr Supply and Drainage Board, Galle Road, Ratmalana..

[2]Civil and Engineering Department, Faculty of Engineering, University of Ruhuna, Hapugala, Galle

**Correspondence E-mail: prasad92pushpika@gmail.com, TP: +94714215458*

Abstract: Due to structural requirement or due to failure of the already constructed pile foundations to carry the intended superstructure loads, it is necessary to use piled-raft foundations. In addition to the above, even if the raft sustains in bearing capacity but fails in settlement, then piled-raft is introduced to reduce the total and differential settlement. Since, this foundation system is not commonly used in the construction industry in Sri Lanka, there is an uncertainty among design engineers regarding the load sharing mechanism of piled-raft system. This paper investigated the load transfer mechanism of the Piled-Raft through literature review. There are 3 types of piled-raft design philosophies namely conventional approach, creep pile approach and differential settlement control approach. Further, based on the above design philosophies, 3 different design methods were compared in this study. Under first design method, piled-raft foundation is divided into several units and estimate the overall settlement by considering the interaction factor between piled-raft units. However, load sharing between pile and raft is not defined in this method. The second design method used piled-raft interaction factor of 0.8 to define the load sharing ratio among the piles and the raft. The third design method is only applicable for strip raft and there are several limitations in this method. Based on the analysis, the second method reported that there was an 6.9% error between actual piled-raft interaction values and assumed value for the selected hypothetical examples. However, by comparing the above design methods, it can be concluded that second design method which use the piled-raft interaction factor of 0.8 gives more reliable analysis.

Keywords: Bearing capacity; Load sharing; Piled-Raft foundation; Settlement

SUSTAINABLE SOLUTIONS

ICSBE 2023-41

A REVIEW: DEVELOPMENT TECHNIQUES FOR MUNICIPAL OPEN DUMPSITE IN DEVELOPING COUNTRIES

K.G.S. Rukshan[1*] and Y.N.S. Wijewardana [2]

[1]*Environmental Authority, Uva Provincial Office, No 179/1, Kappetipola Road, Badulla.*

[2] *Department of Engineering Technology, Faculty of Technological Studies, Uva Wellassa University of Sri Lanka*

**Correspondence E-mail: srukshan73@gmail.com, TP: +94714463239*

Abstract: The quantity and complexity of trash produced has increased as a result of economic expansion, urbanization, and rising living standards in cities. The main factors behind environmental degradation in the majority of developing countries are ineffective management and poor solid waste disposal methods**.** The article illustrates how improperly managed landfills can result in environmental contamination, public health problems, and greenhouse gas emissions, and how managing solid waste is a serious challenge in developing countries. The objective of this article is to review the best methods and affordable strategies for improving municipal landfill efficiency and minimizing harmful effects. The article emphasizes site selection, site preparation, and trash dumping as essential aspects in reducing landfills' environmental impact and the importance of considering local conditions and available resources when implementing landfill maintenance techniques. Low-cost techniques for leachate treatment and landfill gas management are also effective in reducing the release of pollutants and greenhouse gases from landfills. Additionally, manual sorting and recycling are low-cost methods for landfill maintenance that can reduce waste volume and increase resource recovery. The implementation of proper landfill techniques is also highly dependent on the financial resources and technical expertise available in each community in the country. Moreover, other factors such as climate change, waste generation rates, and population growth can affect the effectiveness of these techniques. The review article concludes that implementing low-cost landfill improvement techniques and accurately estimating the time required for stabilization of the municipal landfills can create a sustainable landfill maintenance system that protects public health and the environment in developing countries. And further, this review article gives significant insights into the evolution of landfill management techniques and tactics, as well as sustainable measures to reduce the quantity of trash that ends up in landfills.

Keywords: Municipal landfill; Developing Countries; Waste Management; Environmental Pollution

ICSBE 2023-80

OPTIMIZATION AND SCALE-UP OF PREPARING BATTERY-GRADE GRAPHITE FROM SRI LANKAN VEIN GRAPHITE FOR RECHARGEABLE LITHIUM-ION BATTERIES

H.M.H.D.K. Naranpanawa[1*], T.H.N.G. Amaraweera [1,2], N.W.B. Balasooriya [1,3], K.W.S.N. Kumari [4], H.W.M.A.C. Wijayasinghe [1]

[1]National Center for Advanced Battery Research, National Institute of Fundamental Studies, Kandy,Sri Lanka.
[2]Department of Applied Earth Sciences, Uva Wellassa University, Badulla, Sri Lanka.
[3]Department of Geology, University of Peradeniya, Peradeniya, Sri Lanka.
[4]Department of Science and Technology, Uva Wellassa University, Badulla, Sri Lanka.
**Correspondence E-mail: himashee.na@nifs.ac.lk, TP: +94717900148*

Abstract: The portable energy storage market has witnessed significant growth in the past decade, with Lithium-Ion Batteries (LIBs) emerging as a leading solution. High-quality battery-grade graphite is vital for the anode component of LIBs. Sri Lankan Vein Graphite (SLVG) exhibits exceptional purity and crystallinity, making it a promising candidate. However, to effectively utilize SLVG as an anode material in LIBs, further enhancements to its purity and structure are necessary. This study focuses on practical utilization of SLVG as the anode material in LIBs, through process optimization and scaling up at the laboratory level. Though several methods have been explored for the purification and surface modification of vein graphite, the most effective techniques identified are HCl acid leaching and chemical mild oxidation using HNO_3 acid, respectively. By inventing novel purification and surface modification processes for vein graphite, the National Center for Advanced Battery Research (NCABR) at NIFS has successfully developed battery-grade graphite by showcasing promising performances. It was followed by a comprehensive optimization process in order to determine the optimal conditions for the invented processes, including parameters such as temperature, concentration, weight, volume, and duration, prior to scaling up. The laboratory-level scale-up of these processes was achieved, accompanied by the development of a framework employing linear regression models and the design of experiments. This study reveals that the performance of the graphite samples subjected to the scale-up is comparable to the initial laboratory sample in terms of capacity, rate capability, and cycling life for LIBs anode applications. The successful optimization together with scale-up of the purification and surface modification processes for SLVG pave the way for further advancements in scaling up for industrial-level applications. Additionally, a cost estimation study is necessary to facilitate industrial-level scaling-up with economic viability. The findings of this study will contribute to the progress of battery grade graphite production from Sri Lankan graphite, supporting the development of more efficient and sustainable LIBs for energy storage.

Keywords: Sri Lankan vein graphite; Purification; Surface modification; Li-ion Battery; Scale-up

ICSBE 2023-89

ELECTROCHEMICAL PERFORMANCE OF CuO ANODE MATERIAL SYNTHESIZED BY CHEMICAL PRECIPITATION METHOD FOR RECHARGABLE LITHIUM-ION BATTERIES

W. T. R. S. Fernando[1*], T. H. N. G. Amaraweera [2], H. W. M. A. C. Wijayasinghe[1]

[1] *National Center for Advanced Battery Research, National Institute of Fundamental Studies, Sri Lanka.*

[2] *Department of Applied Erath Sciences, Uva Wellassa University, Sri Lanka.*

**Correspondence E-mail: roshanrsff@gmail.com, TP: +94713638603*

Abstract: CuO has received more attention for the anode application of the rechargeable Lithium-Ion Battery (LIB) than the other competing materials because of its high theoretical capacity (674 $mAhg^{-1}$), good capacity retention, affordability, non-toxicity and ease of storage. The electrochemical performance of CuO mainly depends on crystallinity and morphology, which significantly depend on the synthesizing technique. Simple and convenient chemical precipitation technique, which is a promising technique that enhances the crystallinity with favorable morphology for electrode materials, has not been studied. Therefore, this study aims for synthesizing CuO anode materials by the chemical precipitation technique, with improved crystallinity and morphology. The coin cells were assembled in an argon-filled glove box with anode electrodes fabricated with synthesized CuO, lithium as the reference electrode and counter electrodes together with the non-aqueous electrolyte of 1M $LiPF_6$ in ethylene carbonate and dimethyl carbonate (1:1 wt%). The electrochemical performances have been analyzed by galvanostatic charge- discharge measurements. It was found that CuO electrode exhibited a high initial discharge capacity of 3371.9 $mAhg^{-1}$ at a rate of C/5. The electrode showed a discharge capacity of 442.9 $mAhg^{-1}$ with Columbic efficiency of 97.4%, after 50 cycles. Even though it reported a higher irreversible capacity of 2002.2 $mAhg^{-1}$ at the 1st cycle, it lowered down to 11.4 $mAhg^{-1}$ at the 50th cycle. The enhanced electrochemical performance can mainly be attributed for the enhanced contact surface area for CuO and electrolyte. It could have led to the enhanced contact between CuO and electrolyte and by decreasing diffusion lengths for lithium ions. Electrochemical impedance spectroscopy and cyclic voltammetry analyses also showed improved electrochemical performance. Altogether, this study reveals that CuO synthesized by simple, cost - effective, non - toxic and environmentally friendly chemical precipitation method has very promising electrochemical performance for the anode application of next-generation high - performance LIBs.

Keywords: Anode materials; CuO; Chemical precipitation; Li-ion battery

ICSBE 2023-146

BIO CHAR DERIVED FROM WASTE BIOMASS SOURCES AS A FILLER FOR NATURAL RUBBER: A REVIEW

M.G.D. Sanduranga, R.D.H. Iresha, and C.S. Kalpage*

Department of Chemical and Process Engineering, Faculty of Engineering, Univeristy of Peradeniya.

**Correspondence E-mail: csk@pdn.ac.lk, TP: +94 81 239 3694*

Abstract: Biochar (BCh), a sustainable source of carbon which can be considered as charcoal derived by heating plant materials. Biochar characterized by the porous structure, high carbon content, wide particle size distribution and surface functional groups made it a modern sustainable material in number of engineering applications. Comparable properties of BCh with carbon black (CB) which is considered as the most versatile reinforcing filler in rubber industry, have widen the spectrum of engineering applications of BCh towards achieving sustainable goals. Thus, the current review focuses on identifying BCh as a potential replacement for CB as reinforcing filler for rubber matrices. It is noticeable that physicochemical and mechanical properties of BCh are highly subjective to precursor plant source and processing methods. Nevertheless, it is interesting to note that BCh produced from several natural resources, i.e., saw dust, sugarcane bagasse, maize stover waste, coconut shell and coir waste etc. show high carbon contents of >73 wt% while that of CB is 96 – 99.5 %. High carbon content is a favorable indicator for any reinforcing filler. Furthermore, the ash content and surface area of some BCh are closer to that of CB. Some studies revealed that the surface functional groups found in BCh are almost similar to the functional groups of CB (such as -COOH, phenolic, -OH, amine, amide and laconic) which enhance the reinforcing nature of in elastomeric matrix. Moreover, the fully and partially filled BCh-rubber compounds shows analogous and sometimes superior mechanical properties to that of CB-rubber compounds which clarifies BCh as a prospective filler for rubber industry.

Keywords: Biochar; Natural Rubber; Sustainability; Waste Biomass; Carbon Black; Filler

ICSBE 2023-149

THROUGH THE SHADOWS: AN IN-DEPTH STUDY OF INFORMAL WASTE COLLECTORS' PLIGHT AMIDST COVID-19 IN SRI LANKA

N. Fernando[1*], Y.M.M De Silva [2],

[1]Department of Sociology, University of Colombo,Sri Lanka.

[2]Federation of Local Government Authorities, Sri Lanka

**Correspondence E-mail: nishara.fernando@soc.cmb.ac.lk , TP: +94 77 297 40 37*

Abstract: This study delves into the unprecedented challenges faced by the informal waste collectors in Sri Lanka amidst the COVID-19 pandemic, shedding light on the socio-economic adversities they encountered and the coping strategies they employed. Fifty informal waste workers from the Boralesgamuwa Urban Council and Dehiwala-Mt. Lavinia Municipal Council areas were purposively selected for the study, and thematic analysis was employed to analyse qualitative data. The findings illuminated a cascade of challenges, as informal waste collectors faced reduced interactions with residents leading to an abrupt refusal of services. Further compounding their struggles, the local councils implemented an 11-month ban on informal waste collection, leaving these workers grappling with severe income losses and uncertainty about their future. Adding to their struggles, informal waste collectors faced protests and resistance from their neighbours and residents who feared the potential spread of COVID-19 through waste handling. Amidst these adversities, informal waste collectors displayed resilience, employing various coping strategies to sustain their livelihoods, such as diversifying their income streams by taking up multiple informal jobs, finding alternative employment, and turning to informal lenders for financial assistance. Moreover, some collectors continued to collect economically valuable waste away from the eyes of authorities, salvaging their livelihoods clandestinely. In their pursuit of survival, some reduced the number of meals their families consumed, while others compromised on the quality of food they consumed. Additionally, these waste collectors relied on the support of relatives, neighbours, and friends to obtain loans, handouts, and essential food items. This research underscores the dire circumstances faced by informal waste collectors in Sri Lanka during the COVID-19 pandemic, emphasizing the urgent need for targeted support and policy interventions to safeguard their well-being.

Keywords: Informal waste collectors; COVID-19 pandemic; Socio-economic impacts; Coping strategies

ICSBE 2023-252

DETERMINING THE PRECISE PHYSICAL PROPERTIES OF RUBBER AGGREGATE DERIVED FROM DISCARDED TIRES

B.G.V. Sanjaya[1,2], J.M.R.S. Appuhamy[2], W.M.K.R.T.W. Bandara[2], S. Venkatesan[1], R.J. Gravina[1,3]

[1]School of Engineering, RMIT University, Melbourne, Australia
[2]Faculty of Engineering, University of Ruhuna, Galle, Sri Lanka
[3]School of Civil Engineering, The University of Queensland, St Lucia, Australia
**Correspondence E-mail: s3959393@student.rmit.edu.au/ virajsanjaya@gmail.com, TP: +94 714 771 808*

Abstract: The evolution of the automobile industry has led to the generation of massive amounts of Waste Tire Rubber (WTR), engendering detrimental impacts on the natural environment and human health. Moreover, the non-biodegradable properties of WTR have further escalated the challenges in managing tire-related solid waste only using conventional methods. Hence, it is imperative to introduce a sustainable practice for recycling discarded tires as an urgent necessity. As a result, using Rubber Aggregate (RA) as an alternative aggregate to replace Natural Aggregate (NA) in concrete has been recognized as a promising execution to lessen the above circumstances effectively. Moreover, this approach offers additional benefits, such as providing a timely solution for minimizing the consumption of NA and ameliorating sustainable practices in the construction sector. Nevertheless, previous literature underscored that although plenty of investigations have been conducted to evaluate the performance of Rubberized Concrete (RuC), limited studies have focused on identifying the properties of RA derived from waste tires. Moreover, among these investigations, numerous conflicting findings for specific gravity, bulk density, and water absorption of RA have been reported, highlighting the requirement for further investigations. Hence, conducting a comprehensive investigation to evaluate the precise physical properties of RA is crucial, as the strength reduction associated with RuC can only be lessened by understanding the authentic properties of rubber particles with effective surface treatment methods for modifying the surface texture. Consequently, in this investigation, the variation of specific gravity and water absorption of RA over the saturation period was evaluated as a novel approach to cognize the real behaviour when RA is exposed to water. Moreover, material properties related to RA and Waste Tire Steel Fibers (WTSF) were investigated, and significant deviations compared to NA were recorded for further investigations.

Keywords: Waste Tires; Crumb Rubber; Chip Rubber; Material Properties; Rubberized Concrete

ICSBE 2023-261

LONG SHORT-TERM MEMORY (LSTM) & FEEDFORWARD ARTIFICIAL NEURAL NETWORK (ANN) FOR FLOOD PREDICTION

G.W.T.I. Madhushanka[1*], M.T.R. Jayasinghe [2], R.A. Rajapakse [3]

[1] Department of Civil Engineering, Faculty of Engineering, University of Moratuwa, Moratuwa, Sri Lanka.

[2] Department of Civil Engineering, Faculty of Engineering, University of Moratuwa, Moratuwa, Sri Lanka.

[3] RASU Consulting, New York, USA.

**Correspondence E-mail: tharindumadhushanka111@gmail.com, TP: +94778438195*

Abstract: Nowadays, floods have emerged as one of the most pervasive global environmental and economic hazards, affecting numerous countries across the world, resulting in a staggering loss of both human lives and infrastructure damages. The situation is no different in Sri Lanka. Somawathi, a region in Polonnaruwa district, is often hit by floods be-cause monsoon rains cause the river Mahaweli to overflow. Hence, it is essential to implement a flood forecasting system for mitigating economic losses and minimizing the risk to human lives. Physical-based flood forecasting methods have demonstrated limitations and inefficiencies in their effectiveness because of their tendency to require a large amount of input features. This study aimed to forecast the river Mahaweli flow at Manampitiya Station, which is close to Somawathi, for one day ahead using Machine Learning as the modelling tool and observed rainfall data at three rain gauges and early dis-charges at the target station as inputs. Feedforward Artificial Neural Network (ANN) and Long Short-Term Memory (LSTM) were the used model architectures. Root Mean Squared Error (RMSE) and Nash Sutcliffe Efficiency (NSE) were used for evaluation. Better results were obtained from the LSTM model compared to the ANN model for the same hyperparameters, indicating its superior performance in flow forecasting.

Keywords: flood prediction; water level; long short-term memory; artificial neural network; Mahaweli river; Manampitiya

ICSBE 2023-274

DEVELOPMENT OF UV PROTECTIVE COATINGS TO RETAIN THE COLOR OF GARMENTS USING INORGANIC UV ABSORBERS

D.P.Lokuwithana[1*], L.Palliyaguru[1]

[1]Department of Chemistry, University of Sri Jayewardenepura, Sri Lanka

**dilshani.prathibha97@gmail.com, TP: +94710957076*

Abstract: The rise in clothing consumption has led to unsustainable level of post-consumer waste in the world and making the textile industry as the second largest polluter in the world. Among the numerous garment issues, colour fading of garments stands out as a major issue affecting over half of garment problems. Enhancing the colour fastness to light can significantly increase the lifespan of garments. This study explores the using of nanostructure coating on garment substrates to achieve UV protective textiles, with the focus on inorganic UV absorbers such as TiO_2 and ZnO, that has superior performance over organic UV absorbers. Ultraviolet radiation from the sun can risk to both humans and materials, as it can directly break the covalent bonds in dyes and leads to the formation of free radicals that can oxidize and leading to colour fading of garments. The effectiveness of UV protection is assessed by the ultraviolet protection factor (UPF), with a value of 40-50 considered effective. The study presents the utilization of the PECVD method to develop TiO_2 coating and employs dip coating and screen-printing methods to develop ZnO coating on textile substrates. The colour fastness to light test for fabric was performed using AATCC 16.3, while AATCC TM 183 method was used as the UPF testing method. Fabric samples were further characterized by XPS and PSA techniques.

Keywords: Textile colour protection; Inorganic UV absorbers; Screen printing method; UV protective textiles; PECVD method

ICSBE 2023-322

SPATIAL DISTRIBUTION OF METEOROLOGICAL DROUGHTS IN THE MADURU OYA BASIN IN THE DRY ZONE OF SRI LANKA: IMPLICATIONS OF CLIMATE CHANGE

W.M.R.T.Y. Wijekoon[1*], R.L.H.L. Rajapakse [1]

[1]UNESCO Madanjeet Singh Centre for South Asia Water Management (UMCSAWM), Department of Civil Engineering, University of Moratuwa, Moratuwa, Sri Lanka

**Correspondence E-mail: wijekoonwmrty.22@uom.lk, TP: +94715432572*

Abstract: Assessing meteorological drought occurrences is crucial due to their potential to lead to hydrological droughts and serve as early indicators for preparing against future hydrological drought events. On the other hand, climate change escalates the risk of droughts in the future. Therefore, this study focuses on the spatial distribution of meteorological droughts in the Maduru Oya basin of Sri Lanka, considering potential climate change impacts. The CNRM-CM6-1-HR climate model was selected from the six chosen Coupled Model Inter-comparison Project (CMIP) Global Climate Models (GCMs) based on comparative plots and objective function values obtained during bias correction. GCMs were bias-corrected using the mean-based method and the variance-based method, with the mean-based method being chosen based on the objective function values. To generate maps illustrating the future drought status of the basin, gridded rainfall datasets were developed using CHIRP satellite data for future scenarios, SSP1-2.6 and SSP5-8.5, with bias correction through non-linear power transformation. Drought conditions were assessed using the Standardized Precipitation Index over a three-month time scale to monitor the occurrence of meteorological droughts. Results indicate increased vulnerability to moderate droughts under the SSP1-2.6 scenario during 2015-2100, particularly in the upstream Maduru Oya basin, with moderate drought occurrences ranging from 8% to 10%. In the context of the SSP1-2.6 scenario, extreme, severe, and moderate droughts demonstrate percentage increments of 18%, 16%, and -6%, respectively, compared to the historical period. Notably, there is a substantial rise in moderate droughts in the downstream. Conversely, under the SSP5-8.5 scenario, extreme droughts increase by 31%, severe droughts by 2%, and moderate droughts decrease by 4%. These findings highlight the basin's heightened vulnerability to future droughts, emphasizing the necessity for proactive water resource management.

Keywords: CHIRP satellite data; CMIP6 models; Drought vulnerability; Dry zone basins; Standardized Precipitation Index

ICSBE 2023-359

STRENGTHENING TSUNAMI PREPAREDNESS IN SRI LANKA: AN ASSESSMENT OF THE ACTION PLAN OF TSUNAMI READY RECOGNITION PROGRAMME

K.K.C.L. Kannangara[1*], C.S.A. Siriwardana [2], C. Liyanarachchige [3]

[1]Department of Civil Engineering, RMIT University, Australia

[2]School of Built Environment, Massey University, New Zealand

[3]Disaster Management Centre, 120/2, Vidya Mawatha, Colombo 07, Sri Lanka

**Correspondence E-mail: C.Siriwardana@massey.ac.nz, TP: +94777 555 655*

Abstract: This study evaluates Sri Lanka's implementation of the Tsunami Ready Recognition Programme (TRRP) introduced by the IOC/UNESCO to enhance community preparedness for disasters, specifically tsunamis. The study was prompted by the recent Indian Ocean Wave Exercise (IOWave23), in which the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS) encouraged its member states to test the effectiveness of the UNESCO-IOC Tsunami Ready Recognition Programme (TRRP) indicators or similar national initiatives that intended to strengthen the preparedness at the community level. While the Disaster Management Centre (DMC) of Sri Lanka has outlined an action plan aligning with IOC/UNESCO indicators, the country's current economic crisis presents obstacles to executing these plans. Therefore, this study aims to assist the disaster management officials of Sri Lanka by identifying the priority actions from the action plan. The overall methodology includes summarising key actions under each tsunami-ready indicator and conducting a ranking-type questionnaire with experts who have in-depth knowledge about the current tsunami preparedness at the community level in Sri Lanka. The independent observers of the recent IOWave exercise were invited to participate in this survey given that the exercise already included the testing of tsunami-ready indicators and their involvement in the discussions with the DMC towards identifying the areas for improvement in strengthening the tsunami preparedness in Sri Lanka during the exercise. The study successfully identified priority actions, but only moderate agreement was reached among experts. Among the priority actions identified were the need to develop community tsunami risk reduction plans, map tsunami hazard zones, and have approved tsunami evacuation maps at the community level. The lack of strong agreement among experts may be due to an unclear image of the gaps that need to be addressed at the community level. Therefore, to pinpoint the precise areas for enhancing tsunami preparedness within communities, a thorough evaluation of the existing gaps at the community level is necessary.

Keywords: Community Tsunami Ready Indicators (CTRI); IOWave23; Tsunami Preparedness; Action Plan

ICSBE 2023-357

EXPLORING PERCEPTIONS OF SERVICE DELIVERY IN A LOCAL MUNICIPALITY IN SOUTH AFRICA

E.S. Ngcobo[1], C. Gerwel Proches [1*], N. Singh [1]

Graduate School of Business and Leadership, University of KwaZulu-Natal, Durban, South Africa

**Correspondence E-mail: gerwel@ukzn.ac.za*

Abstract: Post-1994, the current South African government shifted its efforts and policies toward development to address the country's economic and social needs, such as job creation, poverty eradication and promotion of equality. Despite the several reforms initiated by the government, South Africa's challenges, including high unemployment rate, poverty, inequality and poor service delivery, are far from over. Poor service delivery remains critical among these challenges, leading to several protests. Drawing on the qualitative research method, this study seeks to understand perceptions of participants toward service delivery in a local Municipality in South Africa. Based on the thematic analysis that was employed, the study identified the key stakeholders and their roles in service delivery, including municipal officials, ward councillors, ward committees, community members, and suppliers. The study established the role of these stakeholders in service delivery, such as ensuring accountability, managing resources, monitoring and evaluating service providers and projects, service delivery protests, supplying materials and ensuring quality standards. Also, the study found that the nature of services expected by the community members included accessible, affordable, sustainable and quality service. Furthermore, the findings revealed the service delivery challenges facing the municipality, such as issues relating to budget/funding, capacity/staff shortage, lack of accountability, corruption, political deployment and political coalitions. To address these service delivery challenges, the study provides recommendations including appointing competent people, developing a stronger customer-orientation, closer monitoring, more teamwork, demonstrating political will, increasing staff training and communication and avoiding political interference.

Keywords: Service delivery; Government; Municipality; Challenges; Perceptions; South Africa

CIRCULAR ECONOMY

ICSBE 2023-09

EXPLORING CIRCULAR ECONOMY OPPORTUNITIES IN THE BUILT ENVIRONMENT: INSIGHTS FROM CASE STUDY ANALYSIS

Olivia Ho[1], Usha Iyer-Raniga [2*], Kamani Sylva[3], Mahanama Dissanayaka[3]

[1]Faculty of Architecture, Building and Planning, University of Melbourne, Parkville VIC 3010.

[2]School of Property, Construction and Project Management, RMIT University, Melbourne VIC 3001.

[3]Department of Engineering Management, Faculty of Engineering, University of Peradeniya, Sri Lanka.

**Correspondence E-mail: usha.iyer-raniga@rmit.edu.au, TP: +6139925 9066*

Abstract: The built environment is a leading sector that imposes significant pressure on the natural environment. It bears responsibility for greenhouse gas emissions, resource use, energy consumption, and waste generation. Circular economy (CE), which aims to maintain resources at high value, reduce waste generation, and eliminate the use of virgin materials, is a preferred solution for this sector as it minimises environmental impacts and supports achieving sustainable development goals. This paper explores opportunities for applying CE concepts in construction practices through a literature review and qualitative analysis of CE case studies. The case studies from five selected countries, including Australia, Sri Lanka, India, Thailand, and Kyrgyzstan, were collected and analyzed based on the 10R strategies to investigate the application of different techniques. The thematic analysis was employed to analyze case study data. The results reveal that the construction industries in the contexts studied apply a range of CE strategies varying from higher-order to lower-order strategies with or without explicitly referring to them as CE strategies. The research highlights that more comprehensive explanations that incorporate systems thinking, holistic approaches, and life cycle considerations are needed to shift thinking from linear to circular and strategically implement CE strategies in circular construction projects. Further, government-initiated subsidies and a regulatory environment are required to facilitate a region-wide transition to circularity. This study contributes to the knowledge of CE in the built environment. It provides a clear understanding of CE concepts in theory and practice by analyzing CE case studies.

Keywords: Circular economy; R strategies; Case study; Construction; Built environment; Regulation

ICSBE 2023-18

RESOURCE MANAGEMENT IN IRRIGATION PROJECTS OF SRI LANKA USING PRINCIPLES OF CIRCULAR ECONOMY

K.A.G.G.K. Kumarasinghe[1*], K. K. K. Sylva[1]

[1]University of Peradeniya, Peradeniya, Sri Lanka

**Correspondence E-mail: kawshani.k@eng.pdn.ac.lk, TP: +94769639437*

Abstract: The construction industry consumes more than three billion tons of raw materials annually and is responsible for a significant percentage of waste that leads to pollution. Circular eco-nomic concepts have been introduced to solve these critical problems, such as resource scarcity and pollution. The different methods used under the circular economic concept allow the construction industry to rethink designs and make allowances for reducing virgin material. It has been noted that many circular economic concepts are applied in Sri Lankan projects. However, none of these has been appropriately documented for future use. This research aims to identify the details of circular economic applications in the irrigation industry and develop case studies to help prospective design applications. A qualitative study was conducted with a semi-structured interview guide based on the 10R concept to gather data through in-depth interviews from three irrigation projects. The data gathering was terminated after interviewing Twelve (12) respondents once data saturation was reached. Data were analysed by transcribing, coding, and categorizing to investigate the circular economic concepts connected to the cases. Data validation was achieved by using two focus groups and the researcher's observations where necessary. It was observed that Reduce, Reuse, Repair, Remanufacture, and Repurpose, out of the 10R concepts, were practiced in irrigation projects. The quantities of the application of each concept vary depending on the project's scope. According to the results, each case circulated 35% to 100% of tunnel mucking material and more than 50% of excavated soil. This resulted in a reduction in the use of virgin material usage. Apart from that, new R concepts such as Rescale and Responsibility were identified through the research. The irrigation industry could benefit by identifying resources that could be circulated at the inception level of a project to accommodate at the design level for the cost-benefit of both client and con-tractor and effective utilization of public funds on projects.

Keywords: Irrigation Projects; Resource Management; Circular Economy; Circulation.

ICSBE 2023-22

SUSTAINABLE CONSTRUCTION OF TRANSPORT CONNECTIVITY AND ASSET MANAGEMENT PROJECT, SRI LANKA

W.M.S.N. Weerasekara[1*], K.K.K. Sylva[1], S.M. Dissanayaka[1]

[1]University of Peradeniya, Peradeniya, Sri Lanka

**Correspondence E-mail: sandani.weerasekara@gmail.com, TP: +94710933918*

Abstract: The cradle-to-grave concept was practised traditionally in the construction industry, contributing to reducing natural resources and increasing pollution levels with waste. The circular economy (CE) adopts a cradle-to-cradle concept, reducing the adverse effects of a linear economy. Many industries have initiated CE practices, which are now documented for the benefit of future applications. However, CE practices are not common in road construction projects, and applications that have already been practised have not been reported for the benefit of future designs. This case study research was carried out to identify the CE practices in the Transport Connectivity and Asset Management Project (TCAMP) of Sri Lanka, which is funded by the World Bank, considering the case of Andangama Edaduwawa Road. A qualitative study was conducted with a semi-structured interview guide based on the 10R framework. Respondents were selected through a purposive sample identifying professionals and stakeholders involved in the Andangama Edaduwawa Road project. After reaching data saturation, the interviews were terminated at a level of 18 numbers. The data analysis was done by transcribing, coding and categorizing. Identified CE applications from the study were in the categories of Rethink, Reduce, Reuse, Repair, Remanufacture, Repurpose and Recycle. Mostly discussed application, Rubbelization eventually saves around 60 cubic meters, which is an average 9% of the total sub-base material. Further benefits of the application of CE concepts are presented in this paper. Material and time savings resulted from the application of CE concepts; however, significant cost savings were not recorded. Considering the case study, identifying the circularity amount at the design stage could reduce project cost, virgin material usage and waste dumps, benefitting all stakeholders and contributing to sustainable development. The development of similar case studies from the industry is recommended through this research.

Keywords: Sustainable Construction; Roads; Resource Management; Circular Economy

ICSBE 2023-47

A STUDY ON ADAPTATIONS OF CIRCULAR ECONOMIC CONCEPTS IN CONSTRUCTION INDUSTRY OF SRI LANKA

J.M.D.S.D. Jayamanna[1*], S.N.C.M Dias [1], T.D. Denagama [2]

[1]Centre for Environmental Studies and Sustainable Development, The Open University Of Sri Lanka Nawala, Nugegoda.

[2]University of Vocational Technology, 100, Kandawala, Ratmalana.

**Correspondence E-mail: jmdinithi@gmail.com, TP: +94772245252*

Abstract: The construction industry is an important industry which directly contributes to the development of a country but at the same time construction industry is responsible for the considerable environmental impacts due to its consumption of resources, energy, and waste generation. As a new emerging concept, Circular Economy can be used to improve construction industry's resource utilization and waste management. This study is focusing on the circular economic concepts that can be adapted to construction industry by reviewing relevant past literature. The literature review emphasized that green building design, 3R Principle, End of Life considerations, Waste Management concepts are mostly related to circular economy in construction industry. Subsequently, a questionnaire survey was performed to understand the awareness on circular economy in construction industry for academic professionals and working professionals related to construction industry. The results of questionnaires show most of respondents participated to questionnaire survey having knowledge and practicing Recycling & Reusing of construction materials, Green Building design, Energy efficiency Building services & Construction waste management as part of their works. Then an assessment of circular eco- nomic practices used in Sri Lankan buildings was carryout to detect how selected buildings adapted to circular economy features. According to the results of this study, it was understood that in Sri Lanka, circular economy concepts are present mostly in green buildings. Then the study highlights important considerations in design, construction and operational stages of construction related to circular economy in construction industry and it follows recommendations for Sri Lankan construction industry to adapt to circular economy practices including limitations and possible future research options.

Keywords: Circular Economy; Construction Industry; Adaptations; Design Considerations; Green Buildings

ICSBE 2023-62

GHG EMISSIONLESS OPEN DUMPSITE: A CIRCULAR ECONOMY APPROACH

S. Himanujahn[1], W.A.K.S. Fonseka[1,2], D.H.P. Kaushalya[2], M.B.T.D. De Silva[2], R.A.K.K. Perera[3], M. Vithanage[4], B.C.L. Athapattu[1,2*]

[1]Centre for Environmental Studies and Sustainable Development, The Open University of Sri Lanka, Sri Lanka [2]Department of Civil Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka, Nugegoda, Sri Lanka.

[3]Department of Mechanical Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka, Nugegoda, Sri Lanka.

[4]Ecosphere Resilience Research Centre, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka

**Correspondence E-mail: bcliy@ou.ac.lk, TP: +94 77 75 77 321*

Abstract: The practice of open dumping for municipal waste disposal in developing countries contributes significantly to gaseous emissions, including methane (CH_4), carbon dioxide (CO_2), hydrogen sulfide (H_2S), and ammonia (NH_3). Mitigating greenhouse gas (GHG) emissions incorporating circular economy is vital for environmental and air quality improvement. The daily cover with biochar can be identified as a viable solution for absorption of GHGs. While laboratory studies have shown the effectiveness of biochar in reducing GHG emissions, there are lack of pilot-scale assessments and standardized mitigation practices for municipal waste dumpsites. This research was conducted to measure CH_4, CO_2, H_2S, and NH_3 concentrations employing active sampling technique at the five locations of the Karadiyana controlled open dumpsite. The CH_4, CO_2, H_2S, and NH_3 concentrations ranged from 408 to 954 ppm, 1.89 to 84.91 ppm for CH_4, 0 to 2 ppm for NH_3, and 0 to 0.2 ppm respectively. Biochar was prepared using compost residue from the compost plant, which accounted for about 50% of the feedstock. The research demonstrated that the addition of municipal waste biochar as a daily cover significantly improved the landfill cover system, leading to reduced concentrations of landfill gases in the atmosphere by 29%, 63%, 95%, & 67% for CH_4, CO_2, NH_3 and H_2S respectively. The saturation points of biochar were 60, 45, 45 and 30 minutes for CH_4, CO_2, NH_3 and H_2S respectively for a 100 mm effective thickness. Biochar acted as an adsorbent for landfill gases, working in conjunction with microorganisms residing within the biochar pores. This approach offers a solution with circular economy for mitigating GHG emissions from dumpsites and reducing the overall global warming effect associated with greenhouse gases.

Keywords: Biochar; Circular economy; Daily cover; Greenhouse gas; Zero carbon

ICSBE 2023-136

APPLICATION OF CIRCULAR ECONOMIC CONCEPTS AT CONSTRUCTION WASTE MANAGEMENT (COWAM) PROJECT, DADALLA, SRI LANKA

B M M I Balasooriya[1*], K K K Sylva [1]

[1]Department of Engineering Management, Faculty of Engineering
University of Peradeniya,Peradeniya,Sri Lanka.
**Correspondence E-mail: melani.ishara@gmail.com, TP: +94771285297*

Abstract: The construction industry is facing a crisis due to the scarcity of natural resources. Concurrently, the environmental pollution resulting from construction and demolition waste is becoming a burden to the industry and ecosystem function. Linear economic (LE) practices in which the products are discarded at the end of the effective life cycle are responsible for both these problems. Circular economic concepts have become a practical solution to these problems as they give answers to both material scarcity and environmental pollution. In addition, construction waste management after a disaster has become a significant problem for cities. The Construction Waste Management Centre (COWAM) at Dadalla was constructed as a solution to the issues in the management of construction waste after a tsunami hit Sri Lanka in 2004 and is currently being used as a management centre for construction and demolition waste. This case study research was carried out to investigate the present status of the COWAM Centre in relation to circular economic applications. A qualitative study was conducted with ten in-depth interviews using an interview guide based on the 10R circular economy framework. Respondents were chosen using the intensity sampling method, allowing the researcher to select a small number of rich cases that provide in-depth information about the subject of interest. Data was analyzed by transcribing, coding and categorizing to create a circular economic model. Finally, indicators for construction and demolition waste management were identified, and a circular economic model for the COWAM center was created. The COWAM centre could improve further for resource optimization. The scalable and replicable nature of the developed model will allow it to be used in any other city for sustainable development in the built environment.

Keywords: Construction and Demolition Waste; Circular Economy; Sustainability; R concepts; COWAM Centre

ICSBE 2023-138

TRANSITIONS TO PAPERLESS GOVERNMENT OFFICES: AN ANALYSIS OF CHALLENGES AND RECOMMENDATIONS FOR SUPPORTING THE GREEN ECONOMY

Tilak De Silva

Engineering Council Sri Lanka, 230, Bauddhaloka Mawatha, Colombo 7, Sri Lanka

**Correspondence E-mail: thilakrohitha1@gmail.com, TP: +94714753421*

Abstract: This research paper explores the relationship between paper usage in government offices and its impact on the number of trees cut, subsequently affecting the global carbon footprint. Trees play a crucial role in absorbing carbon dioxide from the atmosphere, and their reduction due to increased paper consumption intensifies carbon emissions. Sri Lanka, like many countries, relies heavily on paper-based communications within its government offices. To address this environmental concern and enhance citizen services, the government has invested in Information and Communication Technology (ICT) systems to reduce paper-based communication. However, despite these efforts, the expected results have not been fully realized, leading to continued carbon dioxide emissions from paper usage in the public sector. By analyzing the challenges faced in effectively implementing paperless systems, this research paper provides valuable insights and recommendations to overcome these obstacles successfully. The analysis of multiple case studies revealed several factors contributing to the lack of successful ICT implementation in the government sector. Finally, it will provide how to overcome the challenges and implement effective paperless offices in the government sector.

Keywords: Paper-based; ICT; Paperless; Public-sector; Environment; DMS

ICSBE 2023-266

MANAGEMENT OF E-WASTE IN URBAN SRI LANKAN HOUSEHOLDS

A. S. M. Musharraf [1*], G. P. Jayasiri [2]

[1]CINEC Campus, IT Park, Millenium Drive, Malabe.

[2]Department of Civil Engineering, University of Moratuwa, Sri Lanka

**Correspondence E-mail: muhammed.s0402@gmail.com, TP: +94760507987*

Abstract: Several issues have been raised by the rising amount of electronic waste (e-waste) produced by Sri Lankan households. The growing popularity of electronic devices like computers, mobile phones, and others has become directly accountable for this increase. Inadequate e-waste management procedures put the environment and human health at risk and cause depletion of natural resources. Consequently, looking at the current household e-waste management practices in Sri Lanka is essential in identifying the elements influencing user attitudes about e-waste disposal. This research aims to examine the existing household e-waste management approaches in Sri Lanka and discern the factors influencing how households dispose of e-waste. An online questionnaire survey was distributed to 163 families living in the city of Colombo, Sri Lanka. The results demonstrated that most households sold their e-waste to scrap dealers or discarded with regular garbage. Merely a tiny fraction of households reported utilising formal e-waste collection systems. The study highlighted that lack of awareness regarding the detrimental effects of e-waste and limited accessibility to convenient e-waste collection sites were significant obstacles to household-appropriate e-waste disposal. In addition, variables affecting families' e-waste management behaviours were identified as their educational and income levels. Based on these findings, suggestions have been made to improve e-waste management procedures in Sri Lanka. These recommendations cover initiatives to raise public awareness and educate people about e-waste, promote the development of easily accessible e-waste collection systems, and offer incentives to households to properly dispose of their e-waste. This study is looking to add to the pool of knowledge that is currently accessible about e-waste management and highlight household e-waste behaviours in Sri Lanka.

Keywords: e-waste; Sustainability; Circular economy; WEEE

ICSBE 2023-278

PRIORITIZING GREEN HUMAN RESOURCE MANAGEMENT PRACTICES TOWARDS ACHIEVING ORGANIZATIONAL SUSTAINABILITY FROM EXPERTS' PERSPECTIVES: A CONCEPTUAL PAPER

Mafruha Hossain[1*], Dr. Mohammad Thoufiqul Islam[2]

[1]Assistant Professor, Department of Management Bangladesh University of Business and Technology Rupnagar R/A, Mirpur-2, Dhaka-1216, Bangladesh

[2]Professor, Department of Management Faculty of Business Studies University of Dhaka Dhaka-1000, Bangladesh

**Correspondence E-mail: mafruha@bubt.edu.bd; TP: +880178030274*

Abstract: Adoption of green human resource management (GHRM) is becoming an essential means to reach the Sustainable Development Goals (SDGs) of 2030. As future GHRM policies and plans are being formulated, sustainability and environmental preservation must now be taken into account as a necessary step. Although GHRM has a broad range of applications in HR processes; government and business leaders have been slow to promote and reward it. This conceptual paper attempts to identify the kinds of challenges of implementing green HRM that the leather goods and footwear companies in Bangladesh encounter and trace how they can adopt green HR initiatives and strategies as a part of ensuring organizational sustainability. The leather companies have considerable advancement potential due to the proper use of large but low-cost labor facilities and also for the availability of raw materials, but unfriendly environmental maneuvers create pollution, and in return, they lower the value of the processed leather. Based on resource-based view and just transition theory, this study suggest to occupy primary data from twelve interviewees who are HR experts in this industry and also experts from environmental regulatory bodies in Bangladesh through the Key Informant Interview method. This conceptual paper can garner significant attention and relevance, especially for the leather goods and footwear companies in Bangladesh. The government and non-government authorities who are attempting to deal with, look into, and lessen the hazards posed by industrial pollutants will also be assisted in terms of taking strategic decisions and developing their own green HRM strategies to promote organizational sustainability.

Keywords: Green HRM; Environmental Challenges; Organizational Sustainability; Leather Goods and Footwear Industry.

Technical Co-sponsors

In Collaboration with

Event Partners

INSEE MELWA

Gold Sponsors

SLIIT LTL HOLDINGS

Silver Sponsors

WÜRTH

Bronze Sponsors

BlueScope