Response of shear-critical reinforced concrete frames using the force-based fiber frame elements

Kushan Wijesundara[a*], Sameera Hippola[a]

[a] *University of Peradeniya, Peradeniya, Sri Lanka*

** Email: kushanw@eng.pdn.ac.lk*

Abstract:

In nonlinear analysis of reinforced concrete (RC) frame structures subjected to either seismic or tsunami loadings, an accurate prediction of shear-critical element responses is vital to accurately obtain failure and the overall strength characteristics. However, existing displacement-based finite element modelling techniques require discretization of the elements in a frame structure; or compromise on accuracy by either greatly simplifying or neglecting the axial-moment-shear interaction. Therefore, this paper presents a novel force-based fiber beam-column element that can capture the complex moment-axial-shear interaction response of RC frames. This formulation includes two nested iterations at the structure and the sectional levels. The importance of the sectional level iterations is to explicitly satisfy sectional equilibrium, which is not achieved in either existing displacement or force-based line element formulations. As a result, a stable convergence of all average strain, local crack strain, and slip strain components of the constitutive relationship is ensured. The novel element is validated with experimental results of 170 tests found in the literature. It is shown that the novel element predicts the load carrying capacity well with an average experimental-to predicted load carrying capacity ratio of 0.99 and a coefficient of variation of 12.8%. Furthermore, the element can be used to simulate different failure mechanisms of reinforced concrete frame elements.

Correlating binder chemistry with solid mechanics of cementitious materials

Yuguo Yu[a*], Chamila Gunasekara[a], Yogarajah Elakneswaran[b], Dilan Robert[a], David Law[a], Sujeeva Setunge[a]

[a] *RMIT University, Melbourne, Australia*

[b] *Hokkaido University, Sapporo, Japan*

* *Email: yuguo.yu@rmit.edu.au*

Abstract:

A key challenge in advancing sustainable cementitious materials lies in the absence of rigorous computational methodology to correlate fundamental binder chemistry with solid mechanics. Our latest study introduces a novel multiphysics-coupled framework that bridges this critical gap by integrating kinetic-thermodynamic hydration analysis, multiscale homogenisation, and phase field fracture modelling into a robust unified predictive approach. The innovation transcends beyond isolated material behaviour prediction. Instead, it is capable of establishing a quantitative link between binder-level chemistry and macroscale mechanical performance across diverse cement systems. This presentation will showcase three representative cases to demonstrate the capability and generality of proposed methodology. Firstly, for fly ash concretes with wide-range cement replacements, a time-dependent fracture model is achieved based on computed hydration characteristics, enabling the prediction of compressive strength evolution and fracture energy through a scientifically grounded base. Second, for limestone calcined clay cement (LC3) concrete, the method reveals how variations in metakaolin content and limestone fineness govern strength development through their effect on hydration and microstructure. Third, the framework is extended to engineered cementitious composites (ECC) containing polyvinyl alcohol (PVA) fibre and high-volume fly ash, where a novel phase field model captures the pseudo-ductile, strain-hardening behaviour by linking crack evolution to hydration-driven micromechanics. Across all case studies, the method is validated against experiments and demonstrates predictive power beyond data-driven and conventional empirical models. This work establishes a computationally robust physics-based foundation for next-generation greener material designs, enabling informed optimisation of binder systems to achieve targeted mechanical performance in low-carbon and high-performance construction materials.

Finite element analysis of reinforced concrete beam under fatigue loading: A simplified approach

Danny Triputra Setiamanah[a*], Bambang Piscesa[a], Priyo Suprobo[a], Mudji Irmawan[a], Pannadipa Putera Sukmajaya[a], Dwi Agus Purnomo[b], Djoko Prijo Utomo[b], Wimpie Agoeng Noegroho Aspar[b]

[a] *Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia*

[b] *Center of Technology for Transportation System and Infrastructure (BRIN), Jakarta, Indonesia*

* *Email: 7012212002@student.its.ac.id*

Abstract:

This study presents a three-dimensional nonlinear finite element analysis (3DNLFEA) of reinforced concrete (RC) beams subjected to flexural loading, serving as a baseline for fatigue investigations. Two benchmark specimens (Series 1A and 2A) from the literature were reproduced to validate the modeling framework. Concrete behavior was represented through a multi-surface plasticity–fracture formulation with fracture energy-based softening, while reinforcing steel was modeled using a bilinear elastoplastic law. The model successfully reproduced load–deflection response, crack initiation and propagation, and ultimate failure modes. Numerical predictions deviated from experimental results by less than 5% in ultimate load and 7% in midspan deflection, confirming the robustness of the calibration. Furthermore, simulated crack maps closely matched the observed flexural cracking patterns in the pure-bending region. The validated approach provides a reliable foundation for subsequent fatigue simulations and parametric studies on RC elements.

Keywords: reinforced concrete beam; 3D-NLFEA; plasticity-fracture model; crack pattern

Modelling capillary pore connectivity in textile fibre-reinforced concrete

Hasika Dharmasooriya[a]*, Yuguo Yu[a], Chamila Gunasekara[a], Dilan Robert[a], Sujeeva Setunge[a]

[a] *RMIT University, Melbourne, Australia*

** Email: s3994221@student.rmit.edu.au*

Abstract:

This study presents a computational framework for analysing drying behaviour in Textile Fibre-Reinforced Concrete (TFRC). Moisture transport within concrete is governed by capillary pore (CP) connectivity and porosity evolution, both of which are influenced by hydration kinetics and microstructural changes over time. In TFRC, the inclusion of textile fibres alters internal pore geometry, affecting CP continuity and, in turn, drying behaviour and shrinkage development. The proposed framework integrates hydration modelling with a mixed effective medium theory to quantify the time-dependent evolution of moisture transport properties. A fibre-sensitive percolation function is formulated to characterise changes in CP connectivity resulting from fibre–matrix interactions. This function establishes a direct relationship between fibre characteristics and CP connectivity within the concrete matrix. The framework enables simulation of drying scenarios and supports the identification of fibre configurations that improve water retention and mitigate early-age shrinkage. This approach provides a scientific basis for the design of TFRC mixes with improved dimensional stability and long-term durability, particularly in environments susceptible to drying-induced cracking. By incorporating textile fibre effects into moisture transport modelling, the study advances the development of sustainable cementitious composites with enhanced resistance to moisture loss and shrinkage deformation.

Dynamic testing and system identification of a long-span multi-story building using roving instrumentation setups

Kaveh Andisheh[a,b,c] *

[a] *Tufts University, Medford, USA*

[b] *University of New Hampshire, Durham, USA*

[c] *NZ Heavy Engineering research association (HERA), Auckland, New Zealand*

* *Email: hooman.shirzadi@tufts.edu*

Abstract:

This study presents the results of an in-situ dynamic testing of Building 405 (B405), a long-span, multi-story structure located at the University of Auckland. The building employs a steel–concrete composite structural system, comprising concrete-filled steel hollow section (CFSHS) columns and steel–concrete composite floor systems to resist gravity loads. Lateral loads, including those from high wind and seismic events, are resisted by buckling-restrained braces (BRBs). Due to the building's large footprint, ambient vibration testing was performed in two instrumentation phases. Over several days, ambient responses were captured using 24 accelerometers placed at locations to provide information about vibration modes of interest. To ensure continuity between setups, four reference accelerometers on the 7th floor were kept in fixed positions across both configurations. These reference channels facilitated assemble of identified modal shapes from the two setups. The data-driven stochastic subspace identification (SSI-Data) method was applied to extract the natural frequencies, damping ratios, and mode shapes. This work demonstrates the effectiveness of staged instrumentation and system identification techniques in monitoring long-span structures.

Structural Evaluation of a 1971 Reinforced Concrete Building with Limited Documentation: A Hybrid Experimental-Numerical Approach

Ali Yaghoubzadehfard[a]*, Zhiyuan Zhou[a], Nilupa Herath[a], Massoud Sofi[a], Elisa Lumantarna[a], Priyan Mendis[a]

[a] *University of Melbourne, Melbourne, Australia*

** Email: ayaghoubzade@student.unimelb.edu.au*

Abstract:

This study proposes a comprehensive methodology for the structural health assessment of ageing infrastructure with limited available documentation. The case study involves a reinforced concrete structure constructed in 1971, for which only architectural drawings with a limited technical document are available. An initial finite element model (FEM) is developed based on geometric information inferred from the available drawings and standard material assumptions. To overcome uncertainties arising from the absence of structural and reinforcement details, a suite of non-destructive tests, Schmidt hammer rebound tests and Profometer are employed. The experimental results are used to update and calibrate the FEM, enabling a more accurate representation of the in-situ condition. The refined model is then used to evaluate structural performance and compare results against current design codes. This integrated approach highlights the value of combining limited documents with in-situ testing to support informed decision-making in the assessment and management of ageing concrete. When reassessed against AS 1170 and AS 3600 provisions, the structure failed to meet key performance requirements, particularly in lateral resistance and reinforcement capacity, highlighting the need for retrofit.

Improved Mask R-CNN for Tunnel Rock Saturation Degree and Seepage Area Detection

Shuai Zhang[a,b*], Jun Hu[c,d], Kai Yao[e], Xuemei Liu[b], Zhaokui Sun[c,d], Junxin Shi[c,d], Moirangthem Johnson Singh[e]

[a] *School of Information and Communication Engineering, Hainan University, Haikou, China*

[b] *University of Melbourne, Melbourne, Australia*

[c] *School of Civil Engineering and Architecture, Hainan University, Haikou, China*

[d] *Collaborative Innovation Center of Marine Science and Technology, Hainan University, Haikou, China*

[e] *School of Qilu Transportation, Shandong University, Jinan, China*

** Email: zhangshuai@hainanu.edu.cn*

Abstract:

The saturation of rocks significantly impacts their mechanical properties and construction safety. Accurate and rapid identification of saturation and permeable areas is crucial for the timely correction of construction methods. Therefore, this paper proposes a lightweight deep-learning model for real-time detection of rock saturation. First, infrared thermal images of rock samples with four different saturation grades were collected through indoor experiments. Subsequently, an improved Mask R-CNN model was designed using a more compact convolutional block to extract feature maps. The model was trained on the collected infrared thermal images, resulting in an artificial intelligence model that can be used for real-time detection of rock saturation and permeable areas. The results show that the proposed model outperforms the traditional Mask R-CNN model in performance, with a maximum prediction accuracy of 97% and precise segmentation of water-bearing area boundaries. At the same time, the model's parameters are reduced by 69%, saving a large amount of memory, and the prediction time is reduced by 48%, making it suitable for use in construction tunnels with limited high-performance computing resources. This research has value in reducing the risk of tunnel construction.

Numerical simulation of ship dynamic motion and structural response for structural health monitoring

Ahmed Nisham[a]*, Robert Melchers[a], Robert Petersen[a]

[a] *The University of Newcastle, Newcastle, Australia*

** Email: ahmednisham@uon.edu.au*

Abstract:

Structural health monitoring, maintenance and life extension is an increasingly important set of issues for ships and offshore structures. Particularly the effects of extreme sea-states and structural deterioration cannot be accurately assessed with existing physical tests or numerical methods. Herein a novel numerical simulation approach based on the use of the Finite Point Method (FPM) for generating sea-states and dynamic loadings coupled to Finite Elements (FE) for ship response is outlined and demonstrated in an application to an S-175 containership for which physical model test results are available. It is shown that the FPM-FE coupling approach permits a large decrease in time/cost in mesh generation and can handle large structural deformations including deformations at the fluid-structure interface—capabilities that are difficult to achieve with conventional methods. The numerical results obtained show strong agreement with physical towing tank experiments. These findings along with the significant computational time/cost advantages associated with FPM-FE suggest that advanced, detailed numerical simulation is increasingly viable for response assessment of ships and a wide range of marine structures.

Use of structural reliability principles in building regulation and standards

Lam Pham[a*], Anita Amirsardari [a], Emad Gad[a], Jessey Lee[a], Mark Masia[b], Chi-Hsiang Wang[c], Ken Watson[d]

[a] *Swinburne University of Technology, Melbourne, Australia*

[b] *University of Newcastle, Callaghan, Australia*

[c] *CSIRO, Clayton South, Australia*

[d] *NASH, Hartwell, Australia*

** Email: lpham@swin.edu.au*

Abstract:

Structural reliability is a tool allowing the influence of uncertainties in the parameters used in the design process to be included in building design and assessment. This paper reviews the use of reliability principles in the formulation of Verification Method in the Australian National Construction Code and the derivation of capacity factors for Australian structural design standards. A set of recommendations arising from the above review is proposed for Australia to be consistent with its performance-based regulation and limit states format design standards.

Performance of a ducted cross-flow turbine with different blade configurations for marine current energy extraction

Jai Goundar[a]*

[a] *The University of the South Pacific, Suva, Fiji*

* *Email: goundar.jai@gmail.com*

Abstract:

Marine current energy is a clean source of energy and an alternative energy source to fossil fuel. Horizontal Axis marine current turbine performs well at velocities over 2 m/s and requires an installation depth of 20 - 40 m. Placing an appropriately designed duct or shroud around the turbine significantly improves its performance. A ducted cross-flow turbine (DCFT) was designed and optimized. The experimental results validated the Commercial Computational Fluid Dynamics (CFD) code ANSYS-CFX. The ducted cross-flow turbine's performance analysis with 26-blade, 30-blade, and 36-blade configurations was done at free stream velocities of 1 m/s, 2 m/s, 3 m/s, and 4 m/s. The DCFT with 30 blades configuration performed better than the turbine with 36 blades and 26 blades. A 30-blade rotor achieved maximum efficiency of around 55% at 1 m/s, 2 m/s and 3 m/s. Meanwhile, the 26-blade cross-flow turbine performed slightly better than the 30 and 36-blade turbines at a free stream velocity of 4 m/s with a maximum efficiency of around 56%. The 36-blade cross-flow turbine performs better at lower TSR between 1-2 for the case of 2m/s, 3m/s, and 4m/s compared to 26-blade and 30-blade rotors.

Computer Vision-Based Floor Plan Analysis for Automated Structural Optimisation and Seismic Assessment of Buildings

Prashidha Khatiwada[a]*, Elisa Lumantarna[a], Nelson Lam[a]

[a] *University of Melbourne, Melbourne, Australia*

** Email: khatiwadap@unimelb.edu.au*

Abstract:

While computer vision and image processing techniques have been widely adopted across various engineering domains, their integration into seismic design and vulnerability assessment remains relatively limited. This study presents a novel framework that leverages these techniques to automate and accelerate the evaluation of torsional response in buildings. By processing digital or scanned structural floor plans, the system identifies key load-resisting elements and generates an equivalent frame-pair model that characterises the building's torsional behaviour. The primary objective is to support rapid early-stage design iterations by predicting torsional amplification and optimising wall configurations to reduce torsional effects. This enables informed decisions regarding wall thickness and layout during the conceptual design phase. Moreover, the framework facilitates the conversion of 2D seismic responses into 3D responses—including torsional contributions—critical for city-scale vulnerability assessments that predominantly rely on macroscopic 2D models. The image-based extraction of torsional parameters, in conjunction with the simplified torsional model, streamlines this 2D-to-3D transformation, addressing a longstanding challenge in large-scale seismic simulation. The methodology is demonstrated through two case study buildings, illustrating automated feature extraction, torsional response prediction, and layout optimisation. Comparison with full 3D structural model results confirms the reliability and accuracy of the proposed approach. The framework offers substantial time-saving benefits for both seismic design and vulnerability evaluation processes.

The Role of TechnoLab™ Mini Experiments in Enhancing the Experiential Learning of Basic Mechanics

Jessey Lee[a*], Nicholas Haritos[a,b,c]

[a] *Swinburne University of Technology, Melbourne, Australia*

[b] *University of Melbourne, Melbourne, Australia*

[c] *STRUCOMP P/L, Kew, Australia*

* *Email: jesseylee@swin.edu.au*

Abstract:

ENG10003 *Engineering Mechanics* is a first-year subject at Swinburne University of Technology (SUT), offered in both semesters to differing cohorts of Engineering students. It introduces fundamental Statics and Mechanics concepts, including equilibrium of forces and moments in two and three dimensions, and analysis of simple structures like pin-jointed trusses, beams, and cantilevers. Over the past eight years (excluding the two Covid years), the subject has increasingly incorporated Experiential Learning (EL) using TechnoLab™ experiment kits in its delivery. These include three to four mini experiments (depending on the timetable) and two additional formal experiments held fortnightly during the weekly two-hour practical/tutorial sessions, that complement a semester-long Bridge-Building Assignment. The TechnoLab™ mini experiment rigs allow varied geometric configurations, including different load numbers, locations, angles, and intensities for students working on these in pairs. This ensures no two student pairs share identical parameters, reducing plagiarism and promoting collaborative problem-solving and analysis. Student feedback via Subject Assessment Surveys and informal discussions consistently highlights the EL components as engaging and valuable. In particular, the Bridge-Building Assignment has been frequently cited as the most enjoyable and rewarding part of the subject, despite its intensity. This paper outlines the post-Covid enhancements made to the implementation of TechnoLab™ mini experiments in ENG10003. These improvements have led to deeper student understanding and more effective learning of core engineering mechanics concepts.

Mechanical properties of epoxy-based motars incorporating coal bottom ash, recycled aggregates and fibers

Shahrizan Baharom[a]* , S.M Priok Rashid[a], A.B.M Amrul Kaish[a]

[a] *Universiti Kebangsaan Malaysia, BANGI, Malaysia*

** Email: shahrizan@ukm.edu.my*

Abstract:

Epoxy-based repair mortars are widely utilized in structural rehabilitation due to their excellent mechanical performance and durability. However, the growing accumulation of industrial waste, such as coal bottom ash (CBA) and discarded rubber, presents environmental challenges that demand innovative reuse in construction materials. CBA offers pozzolanic potential and filler properties, while rubber powder enhances flexibility and energy absorption, making them suitable additives for improving the performance of epoxy repair mortars. Hence, the objective of this study was to incorporate CBS with rubber powder and different type of fibers in epoxy to examine their characteristics. Nine mix proportions including only epoxy mix were prepared to evaluate dry density, compressive and tensile strength. The target strength was 50 MPa. The incorporation of coal bottom ash and rubber powder significantly influenced the dry density and mechanical properties of the epoxy-based repair materials. The incorporation of fibers also decreased the compressive strength. The dispersion of the fibers was not uniform in the epoxy mixes. It can be concluded that the results demonstrate that with optimized proportions, CBA and rubber powder can enhance sustainability while maintaining acceptable strength levels for structural repair applications.

Uniaxial tensile strength and fracture energy of one-part ambient-cured geopolymer concrete

Daro Sun[a]*, Jessey Lee[a,b], Alireza Mohyeddin[c], Janitha Migunthanna[a]

[a] *Swinburne University of Technology, Melbourne, Australia*

[b] *Training and Development Manager, Australian Engineered Fasteners and Anchors Council (AEFAC), Melbourne, Australia*

[c] *Edith Cowan University, Perth, Australia*

* *Email: darosun@swin.edu.au*

Abstract:

One-part geopolymer concrete (GPC) offers a practical and sustainable alternative to traditional cement-based materials, particularly for ambient-cured applications. This study investigates the material properties of one-part, ambient-cured slag/fly ash-based GPC. Key mix parameters such as alkali content, slag content, water-to-solid ratio, and aggregate content were evaluated for their influence on compressive strength. Higher slag and activator contents improved early and long-term strength, while excessive alkali or low water-to-solid ratios led to rapid setting. The GPC achieved over 40 MPa at 28 days and 50 MPa at 56 days. Tensile strength and fracture energy were also assessed to characterise mechanical performance.

A New Classification and Readiness Assessment Framework for Self-Healing Concrete Technologies

Yiping Qiao[a]*

[a] *Yeerongpilly, Yeerongpilly, Australia*

* *Email: yipingqiao98@gmail.com*

Abstract:

Self-healing concrete (SHC) is an innovative material designed to autonomously repair cracks, thereby extending the lifespan and resilience of concrete structures. Traditional classifications of SHC—autogenous (natural healing) and autonomous (engineered healing)—are increasingly inadequate given the expanding array of SHC technologies. To address this, a novel classification framework has been proposed, focusing on two fundamental healing mechanisms: substance filling and mechanical closing. The mechanism of substance filling involves the deposition of materials within cracks to restore structural integrity. Examples include bacterial or fungal agents, polymers and superabsorbent polymers and mineral admixtures. The mechanical closing approach relies on materials that can physically close cracks through movement or expansion. Examples include shape memory alloys and polymers, and expansive additives. Additionally, we assign various stages of maturity of Technology Readiness Level (TRL) framework to SHC technologies: high TRL (commercially available or nearing deployment), mid TRL (pilot-scale testing) and low TRL (laboratory research). At the high TRL stage, we have bacterial-based SHC and mineral admixtures. At the mid TRL stage, we have microencapsulation and vascular networks. At a low TRL stage, there are the fungal-based SHC and shape memory materials. This TRL assessment aids in identifying which SHC technologies are ready for implementation, and which require further development.

Sludge-based composite for rapid self-healing cementitious materials in co2-rich environment

Hossein Sanaei Ataabadi[a]*, Yue Liu[a], Jun-jie Zeng[a], Yan Zhuge[a]

[a] *University of South Australia, Adelaide, Australia*

** Email: sanhy012@mymail.unisa.edu.au*

Abstract:

Microbial activity in sewer systems leads to high CO_2 levels generation, reaching 3% noticeably higher than atmospheric concentrations of 0.04%, which has been recognised as an accelerating factor of corrosion in concrete pipes. A novel self-healing capsule was designed for use in CO_2-rich conditions. The capsule formulation included water treatment sludge (WTS) -a byproduct of the water purification industry- combined with calcium hydroxide and expansive agents such as microcrystalline cellulose (MC) and sodium polyacrylate (SPA). The inclusion of the capsules significantly improved the healing performance of concrete under 3% CO_2 exposure within 3 and 7 days. The dual-functional designed capsules contribute to structural durability by preventing further crack development through the rapid expansion of embedded expansive materials (EPMs). Concurrently, the self-repair through the in-situ generation of carbonate-based crystals and calcium silicate hydrate (C–S–H) by pozzolanic reactions of WTS, both of which play key roles in mechanical performance restoration. On average, crack closure rates reached 70% for medium-sized cracks (0.2–0.6 mm) and 60% for larger cracks (0.8–1 mm) after 7 days of curing, increasing to over 90% after 28 days. Water tightness also improved by 60% after 7 days and doubled after 28 days, contributing to significant strength restoration. he healing products mainly consisted of rhombohedral calcite crystals and aluminium-rich phases, with smaller amounts of leaf-like aragonite resulting from pozzolanic and carbonation interactions between WTS and $Ca(OH)_2$. Such findings may help address the challenges associated with sewage pipe degradation and DWTS stock in landfills.

Experimental study of Mechanical Properties of Rubberized Recycled Aggregate Concrete-filled Steel Tube Components

Zheyuan Cao[a]*, Danda Li[a], Xing Ma[a]

[a] *University of South Australia, Adelaide, Australia*

** Email: caozy008@mymail.unisa.edu.au*

Abstract:

This study explores the mechanical performance of concrete-filled steel tube (CFST) members incorporating rubberized recycled aggregate concrete (RRA-CFST) in comparison with conventional recycled aggregate CFSTs (RA-CFST). A total of ten specimens were subjected to axial, eccentric, and flexural loading to investigate peak load, ductility, failure modes, and energy dissipation characteristics. Despite the reduction in compressive strength due to the incorporation of crumb rubber, the confinement provided by the steel tube significantly mitigated strength loss and enhanced deformation capacity. RRA-CFST specimens exhibited good ductility and stable post-peak behavior, particularly under eccentric and flexural loading. Finite element analysis using ABAQUS showed good agreement with experimental data and was further employed for parametric studies on steel ratio and slenderness ratio. The results confirm that RRA-CFST is a promising sustainable alternative for structural applications.

Climate adaptation and resilience for structural systems

Mark Stewart[a]*

[a] *University of Technology Sydney, Ultimo, Australia*

* *Email: mark.stewart@uts.edu.au*

Abstract:

Climate change and sustainability are important challenges for structural engineering, and the need for systems and resilience-led approaches has never been more important. This will allow climate resilience strategies to be carefully considered cognizant of balancing their risks, costs, and benefits to produce the best outcomes for society. Resilience by design will be illustrated with current research of risk-based assessment of climate adaptation engineering strategies including designing new houses in Australia subject to cyclones and extreme wind events. It will be shown that small improvements to house designs at a one-off cost of several thousand dollars per house can reduce damage risks by 70%–80% and achieve billions of dollars of net benefit for community resilience – this helps offset some the predicted adverse effects of climate change for a modest cost.

Influence of structural aspect ratio on the blast response of shaped concrete units

Sreekumar Punnappilly[a]*, Baskar Kaliyamoorthy[a]

[a] *National Institute of Technology, Tiruchirappalli, India*

** Email: sreekumaracademic@gmail.com*

Abstract:

This study investigates the structural response of two distinct concrete structural shapes, square and apsidal, of varying aspect ratios, under blast loading. Spherical charges of an emulsion explosive of three different charge weights are considered at two distinct standoff distances for this parametric study, and the finite element analysis is carried out using the general-purpose finite element code LS-DYNA. Forty-eight simulation runs were carried out. The displacement at a specific node is evaluated for the two structural units, and the results are analyzed. The square unit undergoes higher displacements compared to the apsidal unit for all the scenarios considered in the study. The apsidal unit returns displacement values which are 70 % lower than those of the square unit. Displacement response of apsidal units indicates a uniform increasing trend for the aspect ratios across all scaled distances. Displacement response of square units increases for aspect ratios 0.5 to 1.5 and reversal is experienced for aspect ratio of 2.0.

Numerical Assessment of Honeycomb Cushions for Impact Protection of RC Bridge Girders

Javad Hashemi[a]*, Haider Mraih[a], Robin Kalfat[a], Riadh AL-Mahaidi[a]

[a] Swinburne University of Technology, Melbourne, Australia

** Email: jhashemi@swin.edu.au*

Abstract:

This study presents a numerical investigation into using aluminium honeycomb cushions as energy-absorbing devices to mitigate collision-induced damage in reinforced concrete (RC) bridge girders. Aluminium honeycomb was selected for its lightweight architecture, high energy absorption capacity (EAC), modularity, and ease of integration with existing infrastructure. A detailed finite element (FE) model of the honeycomb cushion was developed in LS-DYNA and validated against experimental data, accurately capturing material behaviour, progressive cell wall collapse, and strain-rate sensitivity. The validated model was subsequently integrated with an RC bridge girder model to simulate horizontal impact scenarios representative of over-height vehicle collisions. The results demonstrated that incorporating the honeycomb cushion significantly enhanced the structural performance, notably reducing the girder's peak impact forces and horizontal displacements.

Repair of Critical Jetty Members utilising in-situ application of CFRP

Liam McGurdy[a]*, Farhad Aslani[b], Ross Herbert[a], Kasia Fornal[a]

[a] *FUZE Group, Perth, Australia*

[b] *University of Western Australia, Perth, Australia*

* *Email: liam.mcgurdy@fuze.solutions*

Abstract:

Structural repairs to jetty structures to date have generally relied on either welding compensation pads or installing clip-on fibreglass jackets. However, the presence of complex geometries in existing jetty elements often makes these conventional methods impractical. In response to such challenges, FUZE Group (Fuze) was engaged to develop an alternative repair strategy. An in-situ Carbon Fibre Reinforced Polymer (CFRP) composite strengthening system was designed and implemented, specifically tailored for environments with restrictions in geometry, access, inspection and timeframe for installation. The system was developed based on a capacity-equivalent (like-for-like) structural design approach, supported by a fracture mechanics-based adhesion model. This design methodology was initially validated using known structural/thermal load cases, allowing the development of an agile analytical framework that could be continuously updated in real time as new inspection data emerged. The outcome was a permanent CFRP solution that was designed to share loads with the remaining substrate material, thereby to maintain integrity of the affected members for the full 20-year target design life.

Hail resistance of high strength dry-cast roofing

Ruizhe Shao[a*], Chaocong Wang[a], Jun Li[a], Chengqing Wu[a,b]

[a] *University of Technology Sydney, Sydney, Australia*

[b] *Institute of Rock and Soil Mechanics, Wuhan, China*

** Email: ruizhe.shao@uts.edu.au*

Abstract:

Increasing climate variability has led to more frequent and severe hailstorms in Australia, posing a serious threat to building envelopes. Traditional roofing tiles, typically made of normal strength concrete, are not only prone to sudden fracture under hail impact but also incapable of withstanding sustained or repeated strikes during extreme hail events. This study addresses these limitations by investigating the structural performance of high strength dry-cast concrete (DCC) tiles with and without fibre reinforcement. At the material level, the mechanical properties of zero-slump high strength DCC were evaluated, with steel fibres incorporated to enhance the toughness and energy dissipation. At the structural level, three-point bending tests and ice ball impact experiments were conducted to assess both static flexural strength and impact resistance of the DCC tiles. The results showed that the optimised mixture achieved a 28-day compressive strength of 98 MPa and a significant enhancement in flexural performance with the addition of 1% steel fibres. For the tile specimens, fibre inclusion improved flexural capacity by over 20% and substantially enhanced post-crack ductility. Hail impact test, conducted using 31.8 mm-diameter ice balls at a velocity of 32 m/s, demonstrated that fibre-reinforced tiles maintained structural integrity and residual load-bearing capacity after multiple impacts, whereas plain DCC tiles suffered from severe cracking, surface spalling, and brittle fragmentation.

Eccentric braced frames: seismic response and design challenges

Kaveh Andisheh[a*], Maryam Hasanali[a], Ali Rad[b], Nandor Mago[a], Károly Jármai[c], G.Charles Clifton[d]

[a] *Heavy Engineering Research Association (HERA), AUCKLAND, New Zealand*

[b] *WSP, AUCKLAND, New Zealand*

[c] *University of Miskolc, Miskolc, Hungary*

[d] *University of Auckland, AUCKLAND, New Zealand*

** Email: kaveh.andisheh@hera.org.nz*

Abstract:

Eccentrically Braced Frames (EBF) are widely used as reliable structural systems for resisting lateral forces, leveraging ductile design principles to achieve a reduction in design-level seismic demands. This paper aims to provide a comprehensive comparison of the seismic performance of EBF systems in accordance with the New Zealand Steel Structures Standard (NZS 3404). To this end, nonlinear analyses are performed on a series of EBF systems with varying shear link lengths and dimensions, to compare the accuracy of the current NZS 3404 in predicting displacement profiles, link rotation demands, and post-yield stiffness. Following that, a detailed nonlinear finite element (FE) model of an EBF system is developed to investigate its cyclic behaviour, focusing on hysteretic responses, energy dissipation mechanisms, and progression of inelastic deformations under repeated loading. Subsequently, a series of case studies, ranging from single-storey to 15-storey buildings, is analysed to evaluate the accuracy and applicability of current design methodology, while also identifying potential challenges associated with its implementation. The results reveal that the current design approach may inadequately reflect the differing seismic behaviours of low- and medium-rise EBF structures, underscoring the need for methodological improvements to ensure more accurate and reliable design solutions.

Linearisation Approach for Overturning Risk Assessment of Tendon-Restrained Rocking Isolated Modular Buildings

Deelaka Jayaweerarathne[a]*, Nelson Lam[a], Elisa Lumantarna[a]

[a] *University of Melbourne, Melbourne, Australia*

* *Email: djayaweerara@student.unimelb.edu.au*

Abstract:

Tendon-restrained rocking isolated modular buildings represent an innovative seismic design approach that allows controlled rocking motion of the building while maintaining structural integrity through prestressing tendons. The rocking isolation of buildings effectively decouples the superstructure from the base, significantly reducing internal force demand on structural elements and enhancing overall seismic resilience of the building. Research to date has identified numerous performance limit states based on rotation angle. However, excessive rotational demands pose significant risks, including potential yielding of the prestressing tendons and, in extreme loading conditions, complete overturning of the structure. These failure modes represent critical concerns that can compromise the fundamental objectives of rocking isolation of buildings. Although rocking isolation technique is well established, a comprehensive method to evaluate the overturning risk of rocking isolated buildings remains undefined. Therefore, this study proposes a systematic approach to assess the overturning risk of tendon-restrained rocking isolated buildings subjected to seismic loading through linearisation. In this approach, Incremental Dynamic Analysis (IDA) is employed to investigate the rotational demand behaviour to predict the maximum angle of rotation under various earthquake scenarios, ensuring compliance with established performance criteria.

Seismic performance of mid-rise composite modular buildings

Omar Morsy[a]*, Huu-Tai Thai[a], Elisa Lumantarna[a]

[a] *University of Melbourne, Melbourne, Australia*

* *Email: omar.morsy@student.unimelb.edu.au*

Abstract:

Modular construction offers advantages over traditional methods, but research on composite modular buildings (CMBs) with concrete-filled steel tubes (CFSTs) for seismic resilience is limited, despite CFSTs' known enhanced seismic properties. This study investigates the seismic performance of a 10-storey CMB with CFST columns, designed for low-to-moderate seismicity, using OpenSees. Advanced nonlinear models simulated CFST columns, beams, and inter-modular connections. Analyses included modal, nonlinear pushover, and nonlinear time history analyses (NLTHA) with 14 ground motions at Baseline Seismicity Earthquake (BSE) and the scaled 3xBSE level. Results indicate Australian Standard underestimates the CMB's fundamental period, ductility, and overstrength. Under BSE, inter-storey drifts (ISDs) were generally within Immediate Occupancy (IO) limits; under 3xBSE, ISDs remained within Life Safety (LS) limits. Residual ISDs were negligible for BSE and below Damage State 1 for 3xBSE, indicating minimal permanent deformation. The CMB demonstrated robust performance, suggesting potential for safe application in moderate and possibly higher seismicity zones, highlighting the need to expand design standards for CMBs.

Predicting time-dependent wind pressure on tall buildings using machine learning

Pasindu Meddage[a*], Damith Mohotti[a], Kasun Wijesooriya[a], Chi King Lee[a]

[a] *University of New South Wales, Canberra, Canberra, Australia*

** Email: p.meddage@unsw.edu.au*

Abstract:

Recent advancements in machine learning (ML) have created new avenues for improving the accuracy and efficiency of wind pressure prediction on tall buildings. Traditional aerodynamic assessment methods rely heavily on wind tunnel testing and computational fluid dynamics (CFD), which are often time-consuming and computationally intensive. This study presents an ML approach to predict time-dependent wind pressures on an isolated tall building under multiple wind directions. Pressure data were generated using validated CFD simulations and were used to train the ML models. The proposed ML models effectively captured both spatial and temporal variations in surface pressure, achieving an R^2 value exceeding 95% during testing. The models demonstrated their ability to generalise across different wind incidence angles while preserving essential flow characteristics around the building. Comparative analysis with CFD and experimental results confirmed the model's accuracy and reliability. This research emphasises the promise of ML models in providing rapid and precise wind pressure predictions, potentially enabling more streamlined structural design processes in modern wind engineering practice.

Simulation of downburst wind flow over different terrain categories

El-Sayed Abd-Elaal Metwally[a]*, Xing Ma[a]

[a] *University of South Australia, Mawson Lakes, SA, Australia*

** Email: elsayed.abd-elaal@unisa.edu.au*

Abstract:

Downburst wind events pose a significant threat to structures, often leading to power line failures and roof damage. These events generate their highest wind speeds at low elevations, making terrain roughness and topography critical factors in wind speed distribution. While the effects of height and slope—such as hills—have been widely studied, the influence of transverse hill or escarpment width has received little attention. Understanding their impact, particularly in combination with other parameters, is essential for accurate design specifications. The results are verified and compared with the corresponding values in the Australian Standards. Based on these findings, design recommendations are proposed to enhance the structural reliability of transmission line systems and related structures.

Characteristic values in Timber Engineering

Lam Pham[a]*, Chi-Hsiang Wang[b], Anita Amirsardari[a], Jessey Lee[a], Emad Gad[a]

[a] *Swinburne University of Technology, Melbourne, Australia*

[b] *CSIRO, Clayton South, Australia*

* *Email: lpham@swin.edu.au*

Abstract:

Characteristic values refer to value of a property for a defined population, determined at a given probability level, such as a mean or 5th percentile, and associated with a particular confidence level, such as 75% or 90%. This concept allows for the standardisation of material properties in timber engineering, supporting both design and quality assurance processes. The current procedures for deriving characteristic values in timber design are outlined in AS 4063.2:2010. Additionally, the ISO 12122 series, published between 2014 and 2018, provides a five-part international standard for determining characteristic values of structural timber products. This paper introduces an alternative approach to establishing characteristic values, which is not covered by the aforementioned standards.

New development in testing and evaluation of timber connections

Anita Amirsardari[a]*, Lam Pham[a], Keith Crews[a], Jessey Lee[a], Emad Gad[a]

[a] *Swinburne University of Technology, Melbourne, Australia*

** Email: aamirsardari@swin.edu.au*

Abstract:

The testing and evaluation procedure for connections is critical for obtaining their structural performance including capacity and stiffness for the design of structures. The current Australian standard for testing and evaluation of timber connections, AS 1649:2001, which includes provisions for nails, screws, bolts, nailplates and brackets, is due for a major revision. Testing and evaluation procedures need to consider the developments that have occurred over the years, including the timber supply, fastener design, and design procedures. Work is currently being undertaken to develop a new industry standard for an updated and more comprehensive testing and evaluation of timber connections to provide an alternative to AS 1649. This paper outlines the historical background of AS 1649, provides an overview of the content of the proposed new industry standard, and discusses possible future developments.

A method for estimating resilience of aging veneer and cavity masonry walls

Chee Yin Lam[a]*, Lyndsey Terry[a], Md Akhtar Hossain[a], Igor Chaves[a], Mark Masia[a]

[a] *The University of Newcastle, Newcastle, Australia*

* *Email: cheeyin.lam@uon.edu.au*

Abstract:

Established cost-effective remediation solutions for unstable masonry wall systems exist, albeit ineffective in detecting the extent of stability loss due to corrosion of wall stability fitments within mortar joints, and thus which walls are prone to imminent collapse. After 24 months in development, a working method for estimating remaining stability and resilience of aging brick veneer and cavity brick masonry walls is proposed. Grounded by in-situ field inspection and condition assessments for various aged veneer and cavity brick walls, the proposed non-destructive in-situ assessment method and associated numerical structural analysis model have been validated and calibrated against detailed experimental corrosion science testing of wall metal stability fitments. This presentation aims to provide details surrounding the method's development and showcase applicability of the corrosion science-based numerical model.

The impact of corrosion on the behaviour and strength of wall ties in cavity brick walls

Lyndsey Terry[a*], Chee Yin Lam[a], Igor Chaves[a], Mark Masia[a]

[a] *The University of Newcastle, Callaghan, Australia*

** Email: lyndsey.terry@uon.edu.au*

Abstract:

Wall ties are a metal fitment used in masonry walls that provide an important connection between the external leaf of masonry and the internal wall or frame. In a cavity brick wall, the internal wall is masonry, mirroring the external wall, with an air cavity in between. The wall tie is embedded in both leaves of masonry and, in the event of strong winds or an earthquake, transfers lateral loads between them. Inevitably, the wall ties experience losses due to corrosion mechanisms occurring within the microenvironments of the cavity wall. The present study reports on the axial tension and compression testing results of cavity brick wall subassemblies, comparing the findings of non-corroded and artificially corroded wall ties. The impact corrosion losses have on the behaviour of the wall ties in tension and compression are useful for understanding when a cavity brick wall might be vulnerable to collapse. Subassembly specimens represent a single connection, and hence numerical models were also completed to show the behaviour of the cavity wall when corrosion losses are induced to the wall ties within a full-scale wall.

Condition assessment of wall ties in masonry cavity wall using vibration-based methods

Chee Yin Lam[a]*, Mark Masia[a], Igor Chaves[a], Md Akhtar Hossain[a]

[a] *The University of Newcastle, Callaghan, Australia*

** Email: cheeyin.lam@uon.edu.au*

Abstract:

Assessing the condition of wall ties in masonry cavity wall systems using a non-destructive approach is challenging due to the hidden nature of installation and subtle wall tie deterioration mechanisms. This study presents a vibration-based damage identification approach to address this issue using the impact hammer test. The test measured the natural frequencies and the corresponding mode shapes of a one-story masonry cavity wall with six different test cases of wall tie deterioration. A significant reduction in natural frequencies of up to 64% was observed when all wall ties were fully cut, indicating the suitability of using natural frequency as a damage detection indicator. In terms of damage localization, four mode shape-based analyses were compared and discussed, including the coordinate modal assurance criteria (COMAC), parameter-based method, curvature damage factor (CDF) and mode shape derivative-based damage identification method (MSDBDI). Among the four-mode shape-based methods, parameter-based and CDF methods demonstrated high accuracy in locating damage locations by identifying high damage indices near the affected regions. The findings highlight the potential of vibration-based damage identification methods for the detection of wall tie deterioration and contribute to a more robust structural risk assessment for masonry structures.

Stress relaxation prediction of basalt fiber reinforced polymer (BFRP) under flexural loads based on time series parameter method

Xing Ma[a]*, Wuxiang Liu[b]

[a] *University of South Australia, Adelaide, Australia*

[b] *Tongji University, Shanghai, China*

* *Email: xing.ma@unisa.edu.au*

Abstract:

Stress relaxation phenomenon is one of the key influencing factors that govern long term mechanical behaviour of basalt fiber reinforced polymer (BFRP) in structural applications. This paper proposes a prediction model for the flexural stress relaxation behavior of BFRP plate through applying a time series parameter method (TSPM) in experimental data processing. To improve the accuracy of the model, sub-data-groups are selected from the experimental data base. Individual prediction formulas are simulated by direct extrapolation functions based on each sub-data-group, respectively. It should be noted that the coefficients in the individual prediction formulas from different sub-data-groups are different. To develop a general prediction formula, coefficients in the formula are replaced through undetermined time-related coefficient functions, which can be fitted through all the individual coefficient values from sub-data-groups. Thus, a general prediction equation that considers the characteristics of all sub-data-groups is constructed. Finally, an experimental study on two BFRP specimens is conducted through three-point bending tests. Two sub-data-groups are used to predict the experimental results through the TSPM method. Comparison between prediction results and experimental data verifies that the proposed TSPM method is with high precision and is more accurate than the traditional extrapolation function fitting method as time grows.

Numerical study on the hollow-core FRP-concrete-steel column against close-in blast loa

Weiqiang Wang[a*], Kang Li[a], Huafeng Yu[b], Kaien Jiang[b]

[a] *Hohai University, Nanjing, China*

[b] *PowerChina Huadong Engineering Corporation Limited, Hangzhou, China*

* *Email: weiqiang.wang@hhu.edu.cn*

Abstract:

This study numerically investigated the behaviour of hollow-core FRP-concrete-steel (HC-FCS) column against close-in blast load. The Arbitrary Lagrangian Eulerian (ALE) algorithm was used to study the blast wave propagation as well as the interaction between the blast wave and HC-FCS column. The accuracy of the numerical model was first validated using the test results on the concrete-filled double skin steel tubular column. Based on the validated numerical model, the blast wave propagation, concrete damage development, effective stress distribution of steel tube and FRP tube's hoop strain were analysed. The numerical results demonstrate that the HC-FCS column exhibits satisfactory behaviour against the close-in blast load, and the FRP tube is able to effectively protect and confine the infilled concrete at the blast region during the close-in blast.

Optimizing UHPFRC performance: A study on hybrid steel fiber blends and their mechanical-microstructural effects

Mudassir Iqbal[a,b]*, Xiao-Ling Zhao[a], Daxu Zhang[b]

[a] *The Hong Kong Polytechnic University, Kowloon, Hong Kong*

[b] *Shanghai Jiao Tong University, Shanghai, China*

* *Email: mudassir.iqbal@polyu.edu.hk*

Abstract:

Floating structures are gaining recognition as versatile solutions for renewable energy platforms, floating bridges, transport infrastructure, floating cities, offshore industrial and storage facilities, aquaculture, and recreational applications. However, most offshore foundations currently depend on steel, a material susceptible to corrosion and fatigue under prolonged exposure to seawater, humidity, and dynamic loading. These degradation mechanisms not only compromise structural longevity but also result in significant maintenance costs. Instead, ultra-high-performance fibre-reinforced concrete (UHPFRC) offers a durable alternative to steel in marine environments. For floating structures to perform effectively in marine environments, UHPFRC must meet stringent mechanical and operational requirements. While UHPFRC has been extensively studied with micro steel fibers, limited research exists on the hybrid use of micro and macro fibers to optimize its performance. Therefore, this study evaluates the mechanical and microstructural performance of UHPFRC using several combinations of micro and hooked steel fibers. Four different mixes (Control (0% fibers), 2MS0HF (2% micro steel and 0% hooked fiber), 1MS1HF (1% micro steel and 1% hooked fiber) and 1.5MS0.5HF (1.5% micro steel and 0.5% hooked fiber) were evaluated for compression and flexural strength. Three samples were tested for compression, and four samples were tested for flexural analysis for each combination. From load-deflection curves, the first cracking, post-cracking flexural strength, flexural deflection capacity, and flexural toughness were determined. The microstructural performance, i.e., SEM, XRD, and BET analysis, supported the mechanical evaluation. Comments were made on the usage of hybrid combination of fibers for floating structures applications.

Numerical investigation of a syntactic foam layer for enhancing load distribution and durability in FRP deck system

Khaja Kamal Fayaz Ahmed[a]*, Anil Agarwal[a]

[a] *Indian Institute of technology Hyderabad, Hyderabad, India*

** Email: ce22resch11003@iith.ac.in*

Abstract:

The performance of fibre-reinforced polymer (FRP) deck systems under concentrated wheel loads is often limited by their vulnerability to damage at the interface between the surfacing pavement and the deck structure. This can lead to the detachment of surface fragments, causing progressive wear of the underlying deck structure and ultimately reducing its service life. To address this limitation, a lightweight syntactic foam layer composed of micro-glass bubbles, and a polymeric resin matrix is introduced between two FRP deck surfaces. This layer is designed to enhance load distribution, reduce stress concentrations, and prevent damage propagation into the deck structure. In this study, a detailed numerical investigation is conducted to assess the effectiveness of the syntactic core sandwiched between two FRP layers. The FRP deck is modelled using mechanical properties and failure initiation parameters derived from a representative volume element (RVE), with damage progression simulated using Hashin's failure criteria. The syntactic foam is modeled using the Concrete Damage Plasticity (CDP) model, calibrated through experimental data obtained from uniaxial tension, compression and cyclic tests. Further, numerical simulations were performed under patch loads replicating realistic service conditions. The foam layer's thickness is refined to balance weight efficiency and mechanical performance. This integrated system shows potential for enhanced structural performance, uniform load distribution and increased load capacity of FRP deck systems, particularly in applications where repeated or concentrated loads are expected.

An autoencoder-based approach for barely visible impact damage detection in CFRP panels

Sina Mansourdehghan[a]*, Farhad Aslani[a], Du Huynh[a], Peter Butt[b], Sriram Ravisankar Padma[a]

[a] *University of Western Australia, Perth, Australia*

[b] *Fuze Solutions, Perth, Australia*

* *Email: sina.mansourdehghan@research.uwa.edu.au*

Abstract:

Barely visible impact damage (BVID) in carbon fibre-reinforced polymer (CFRP) structures poses a significant challenge for structural health monitoring (SHM), as such damage may not be detectable through visual inspection but can have a critical impact on structural performance. Fibre Bragg grating (FBG) sensors provide high-resolution spectral data capable of capturing subtle strain variations; however, extracting meaningful damage-related features from these signals remains complex, especially without prior knowledge of the damage scenarios. This study proposes an unsupervised approach to detect BVID in CFRP panels using full-reflectance spectra from FBG sensors. A total of 2,344 spectral signals, including both damaged and undamaged structures, were collected from three flat-stringer reinforced panels subjected to controlled impacts across three severity levels. To avoid reliance on scenario-specific labels, convolutional autoencoders were trained solely on pristine (pre-impact) signals to learn normal spectral characteristics. All signals were then passed through the trained autoencoders, and the reconstruction error, which quantifies the difference between the original and reconstructed spectra, was extracted as a damage-sensitive feature. Results showed a strong correlation between reconstruction error and the severity of damage. K-Means clustering applied to these features achieved 79.5% accuracy in distinguishing damaged from undamaged states. This study highlights the potential of reconstruction error as a robust, scenario-independent indicator for unsupervised damage detection, providing a scalable path toward real-time SHM in composite structures.

Large deformation behavior of lattice structure in compression: Experiments, finite element analysis and analytical modelling

Jianjun Zhang[a]*

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

** Email: joelzhang@swin.edu.au*

Abstract:

Lattice structures have garnered significant attention in industrial applications due to their exceptional mechanical properties and superior energy absorption capabilities. The nonlinear response of these structures under extreme loading conditions can critically influence their mechanical performance and safety. While previous studies have predominantly focused on the parametric properties of lattice structures in the linear elastic phase, there has been limited exploration of their plastic large deformation behavior. In this study, the BCC lattice structure was selected, and several samples were fabricated by selective laser melting (SLM) method using 316L stainless steel (316L SS) to systematically analyze the compressive behavior of the structure during the plastic large deformation stage. A theoretical model was developed based on an idealized deformation mechanism and subsequently validated through finite element (FE) analysis and experimental methods. The influence of geometrical parameters on the compression response of lattice structures was thoroughly investigated, and the applicability of the theoretical model was critically discussed.

Numerical investigation of hydrogen-air cloud detonation: Validation with field experiment and effect of equivalence ratio on overpressure

Wimukthi Senarathna[a*], Damith Mohotti[a], Kasun Wijesooriya[a], Edward Chern Jinn Gan [b], Zhenying Huang[b], Alex Remennikov[b], Chi King Lee[a]

[a] *The University of New South Wales, Canberra, Australia*

[b] *University of Wollongong, Wollongong, Australia*

** Email: w.senarathna@unsw.edu.au*

Abstract:

The potential of hydrogen as a clean energy carrier is accompanied by explosion risks, particularly in the detonation mode of hydrogen-air mixtures. This study presents a combined experimental and numerical investigation of unconfined hydrogen-air detonation in a 5.09 m^3 cylindrical setup. A field experiment using PETN initiation measured overpressures at various distances. A novel numerical modelling framework was developed using detailed chemical kinetics, finite-rate turbulence-chemistry interactions, and an Embedded Large Eddy Simulation (ELES) approach. The model was validated against experimental data, showing strong agreement in peak overpressure, pressure profiles, and shock arrival times. The effect of equivalence ratio (ϕ = 0.2–5) on detonation behaviour was investigated. Detonation was observed between ϕ = 0.65 and 4.5, with a peak overpressure of 217.7 kPa at ϕ = 1.5. The study defines detonation limits and provides critical insight into overpressure trends and peak loading risks. These findings support improved safety assessment and infrastructure design for hydrogen applications in open environments.

Experimental investigation of laboratory-scale hydrogen deflagration explosions

Zhenying Huang[a*], Edward Chern Jinn Gan [a], Alex Remennikov[a], Ting Ren[a], Damith Mohotti[b], Kasun Wijesooriya[b]

[a] *University of Wollongong, Wollongong, Australia*

[b] *The University of New South Wales, Canberra, Australia*

** Email: zh786@uowmail.edu.au*

Abstract:

Hydrogen's potential as a clean energy source necessitates a comprehensive understanding of its explosion characteristics to ensure safe deployment. Building upon previous large-scale unconfined hydrogen-air explosion tests, this study presents a newly developed 1:10 laboratory-scale experimental setup designed to capture flame propagation and blast parameters with enhanced resolution. The system integrates schlieren imaging for visualising flame front evolution and pressure sensors for capturing incident and reflected overpressures. Preliminary results reveal that the scaled experiments reproduce key trends observed in the field tests, including flame acceleration and characteristic deflagration overpressure profiles. However, peak overpressures and flame velocities are reduced at the laboratory scale, attributed to geometric constraints limiting flame development. Comparative analysis based on scaled distance shows good agreement in waveform shape and highlights the significance of the negative pressure phase, which may play a critical role in the structural response. This study demonstrates the utility of small-scale experiments for understanding hydrogen deflagration dynamics and informs future scaling analyses and blast-resilient design strategies.

Experimental analysis of projectiles expelled from mine openings due to underground coal mine explosions

Edwin Chern Junn Gan[a]*, Edward Chern Jinn Gan[a], Alex Remennikov[a], Ting Ren[a]

[a] *University of Wollongong, Wollongong, Australia*

** Email: ecjg909@uowmail.edu.au*

Abstract:

The safety of personnel working in coal mines is a critical concern that requires a comprehensive understanding of explosion dynamics, mining operations, and safety protocols. While gas explosions in underground mines have been considerably studied, far less attention has been given to the risks posed by projectiles expelled through mine openings. These hazards can lead to severe injuries, fatalities, and significant damage to aboveground infrastructure. Previously, the authors successfully developed a methodology for prescribing exclusion zones around mine entrances against blast wave hazards. To address projectile hazards, the methodology from the NATO manual AASTP-1, originally intended for ammunition storages, was adapted for mining in the interim. This project expands on that work through experimental studies using innovative test setups that replicate horizontal drifts and vertical tunnels (shafts and boreholes). For the first time, the effect of drift inclines on projectile safety distances is studied experimentally as it is anticipated that steeper inclines may increase projectile range. The proposed methodology is based on establishing a relationship between blast parameters around mine openings (total pressure and impulse), projectile characteristics (shape, size, and mass), and resulting projectile behaviour (initial velocity and trajectory angle). Experiments are conducted using an Advanced Blast Simulator (ABS) with a 0.3 m × 0.3 m cross-section to simulate blast waves and projectiles expelling from horizontal drifts and vertical tunnels. The outcome of this project will support the development of science-based guidelines for defining exclusion zones around mine openings.

Using artificial intelligence in the blast load prediction of unconfined hydrogen deflagrations

Kirilous Gindie[a]* , Edward Gan[a], Alex Remennikov[a], Ting Ren[a]

[a] *University of Wollongong, Wollongong, Australia*

** Email: kmyg354@uowmail.edu.au*

Abstract:

The accurate prediction of blast loads plays an essential role in hydrogen-related infrastructure safety. This study proposes an artificial intelligence (AI) approach for predicting key blast load parameters such as peak positive overpressure, peak underpressure, positive phase impulse and negative phase impulse resulting from unconfined hydrogen deflagrations. A database of 550 data points was generated using Viper: Blast by varying flame speed, ignition height and standoff distance. A multi-layer perceptron model was developed and trained on the generated database with six input variables: cloud radius, cloud height, hydrogen concentration, ignition position, flame speed, and standoff distance. The trained model achieved a coefficient of determination (R^2) of 0.99 and was evaluated on an unobserved scenario. A SHAP analysis identified that flame speed, ignition height and standoff distance were the influential inputs matching the trends observed within the CFD-generated dataset. The prediction where then compared to computational fluid dynamics simulations from Viper: Blast and the empirical BST model. The AI-predicted blast loads compared to the CFD-generated values with prediction errors were between 0% and 6% across all the gauge locations. These results demonstrate that AI models can generate high-fidelity predictions with a reduced computational requirement. This approach offers engineers an accurate avenue for estimating blast loads from unconfined hydrogen deflagrations which is valuable for early-stage structural design and hazard assessment.

Mechanical performance of 3D printed continues fiber-reinforced composite metamaterials

Dong Ruan[a*], Varnith Diwakar[a], Azadeh Mirabedini[b], Kwong Ming Tse[a]

[a] *Swinburne University of Technology, Melbourne, Australia*

[b] *RMIT University, Melbourne, Australia*

** Email: druan@swin.edu.au*

Abstract:

This study investigates 3D-printed gyroid structures fabricated using continuous fiber-reinforced composites (CFRCs) via fused filament fabrication. X-ray CT imaging was used to visualize internal void patterns, revealing voids in Onyx primarily in the infill region due to bead placement, while in GFF/Onyx, voids were mainly located at the fiber–wall interfaces, especially in high-curvature areas. The research was conducted in two phases to examine structural performance. Firstly, a comparative analysis of Onyx and Onyx reinforced with glass fiber filament (GFF/Onyx) gyroid structures was performed under quasi-static compression in the three orthogonal directions. Results showed higher stiffness and lower specific energy absorption (*SEA*) due to interlaminar failure in the *X* and *Y* directions, while the *Z* direction exhibited stable progressive folding with higher *SEA,* an attribute of printed bead alignment. In the second phase, quasi-static and dynamic compressive tests were conducted on gyroid structures made from Onyx, Onyx reinforced with GFF, Kevlar fiber filament (KFF/Onyx), and carbon fiber filament (CFF/Onyx). Under dynamic loading, Onyx structures showed fragmentation, while fiber-reinforced variants maintained structural integrity due to fiber bridging. GFF/Onyx exhibited the highest plateau stress under both loading conditions, while KFF/Onyx demonstrated the greatest strain rate sensitivity, with a 67.43% increase in plateau stress and 84% in *SEA*. The study provides valuable insights into the influence of fiber type, loading direction, and velocity on the mechanical performance of 3D-printed CFRCs gyroid structures.

Numerical homogenisation of porous composite materials via Scaled Boundary Finite Element Method

Da Chen[a]*

[a] *University of New South Wales, Sydney, Australia*

** Email: daniel.chen7@unsw.edu.au*

Abstract:

Porous composite materials made of foams are gaining traction in various industrial sectors, and are featured with light weight, high specific stiffness, good energy absorption, and novel thermal, biological, acoustic characteristics. They give unique flexibility in performance-tailoring and possess great potential in multi-functional applications. Highlighted by random cellular geometries, porous materials play an important role in advancing various engineering fields. One of the key difficulties in applying porous materials lies in the lack of effective and efficient examination methods, induced by the highly irregular and complex geometries and cellular randomness. This work innovatively adopts scaled boundary finite element method (SBFEM) to assess the mechanical responses of porous materials via representative volume elements (RVEs). The existing tools for FE homogenisation of porous materials generally include commercial software such as ANSYS and ABAQUS for simulating the mechanical behaviours. However, originated from the aforementioned complex morphologies of random porous materials, these simulations via software are often time-consuming with overly large node numbers and frequently encountered meshing failures. Applying SBFEM will effectively address this problem, leveraging its superior quad-tree and octree meshing strategies and S-element assembly. This study will reveal the advantages of using SBFEM in porous material FE homogenisation, highlighted via a direct comparison with ANSYS/APDL, regarding the computational efficiency and accuracy, as well as the applicability in different calculation scenarios.

Energy absorption characteristics of menger fractal cubes

Damith Mohotti[a]*, Kasun Wijesooriya[a], Madhusha Bogahawaththa[a], Chi-King Lee[a]

[a] *University of New South Wales, Canberra, Australia*

* *Email: d.mohotti@unsw.edu.au*

Abstract:

Porous structures produced via selective laser melting (SLM) offer significant potential for impact mitigation due to the ability to tune their mechanical behaviour. The Menger Fractal Cube (MFC), a hierarchical structure formed through iterative void removal, exhibits a complex self-similar geometry that enhances energy dissipation while maintaining a lightweight form. This study explores the compressive response of MFCs with three fractal orders, fabricated from AlSi7Mg, through experimental testing. Digital image correlation was utilised to map stress distribution during elastic deformation. Collapse mechanisms, fracture patterns, and energy absorption efficiency were analysed, revealing that third-order MFCs achieved superior specific energy absorption and densification displacement. Furthermore, increasing fractal order corresponded with reduced peak force, highlighting the viability of high-order MFCs as sacrificial protective structures. These findings highlight the potential of MFCs for applications requiring high energy dissipation and controlled force transmission, particularly in protective and impact-resistant designs.

Effect of the density gradient on the mechanical behavior of an architectured material under dynamic loading

Manish Kumar[a,b]* , Louise Le Barbenchon[b], Juan Pablo Escobedo-Diaz[c], Paul Hazell[c], Philippe Viot[b]

[a] *University of New South Wales, Canberra, Australia*

[b] *Arts et Metiers Institute of Technology, Talence, France*

[c] *University of New South Wales, Canberra, Australia*

* *Email: manish.kumar1@unsw.edu.au*

Abstract:

Architectured cellular structures are usually manufactured by additive manufacturing [1] due to their small sample size. This work aims to develop a new type of architectured structures using a conventional foundry process. Very few cellular materials, such as foams and periodic cellular materials, have been successfully fabricated by casting. Thus, there remains a significant gap in understanding the mechanical behaviour of such cast structures, especially under dynamic loading conditions. Quasi-static compression and dynamic tests are performed on cylindrical samples made of AlSi7Mg0.6 and pure aluminium made up of Kelvin unit cells. The specimens measure 100 mm in diameter and 90 mm in height. Finite Element simulations were conducted using explicit and implicit solvers, calibrated with experimental data to model the nonlinear response, including material plasticity, large deformations, and geometric instabilities. The computational results exhibited good agreement with experimental force-displacement curves, stress-strain behaviour, and energy absorption capacities. Specific Energy Absorption and Energy Absorbed at Densification were computed for performance comparison across materials and geometries. Initial results indicate that cast aluminium Kelvin structures deform via a progressive collapse mechanism: beginning with elastic buckling, followed by local plastic deformation, and culminating in densification. The simulations accurately capture strain-rate-sensitive behaviour and align closely with experimental observations. This integrated computational–experimental approach offers new insights into the behaviour of cast cellular metals and provides a pathway for designing next-generation energy absorbers with density gradients for impact-critical applications.

Sustainability evaluation of foundation systems: A comparative life cycle analysis of screw piles and bored piers

Janitha Migunthanna[a*], Amanda Huang[a], Mark Armstrong[b], Miles Opacic[c], Pathmanathan Rajeev[a]

[a] *Swinburne University of Technology, Melbourne, Australia*

[b] *Katana Foundations, Melbourne, Australia*

[c] *IdealCorp Pty Ltd, Sydney, Australia*

* *Email: jmigunthannakariyaka@swin.edu.au*

Abstract:

The foundation is a crucial element of any structure, responsible for transferring loads to the ground. Beyond ensuring the structural integrity of the foundation system, its sustainability is equally important, as enhancing the environmental performance of foundations plays a key role in advancing sustainable construction practices. There are different types of foundation systems, and their applicability varies on the type of the building and the soil conditions. The main objective of this research is to evaluate the sustainability of screw piles (SP) and bored piers (BP) through a life cycle analysis (LCA) from the perspectives of carbon emission and energy consumption. A cradle-to-grave LCA is performed for the pile systems, starting from the manufacturing to the end-of-life, to quantify the associated global warming potential (GWP) and energy consumption (EC) of both BP and SP. This study follows a process-based approach, where individual processes associated with each life cycle stage are considered separately in analysing the total impacts. The LCA results indicate that screw piles have over-all less impacts compared to bored piers at each life cycle stage. For an average job under nor-mal circumstances (i.e., standard material and machinery use, normal weather), screw piles showed a 56% reduction in GWP and a 34% reduction in EC compared to an equivalent bored pier system.

Modelling reinforcement corrosion initiation time in silica fume concrete sea walls using random field theory

Yanni Bouras[a]*, Le Li[a]

[a] *Victoria University, Footscray, Australia*

** Email: yanni.bouras@vu.edu.au*

Abstract:

Due to its strength and chloride resistance improvement, silica fume concrete (partially replacing cement with silica fume in concrete manufacturing) has been increasingly used in coastal structures. However, studies are lacking that predict the corrosion initiation time of reinforcement in coastal structures made with silica fume concrete, considering the spatial variation of concrete mix design and using the time-dependent reliability method, while this initiation time prediction is essential to develop a reliable maintenance schedule for coastal structures. To overcome this limitation, this paper established a new framework combining the chloride diffusion model, time-dependent reliability analysis and random field theory for corrosion initiation prediction of reinforcement in silica fume concrete coastal structures subjected to chloride attack. The application of such a platform was demonstrated through a working example- a sea wall structural system, which indicates the platform can help asset managers predict reinforcement corrosion initiation time in concrete coastal structures.

Fibre optic based structural health monitoring of interfacial disbond evolution in bonded FRP-steel systems

Sriram Ravisankar Padma[a*], Farhad Aslani[a], Peter Butt[b], Angus Tavner[a], Prashanth Nagulapally[a], Sina Mansourdehghan[a]

[a] *The University of Western Australia, Perth, Australia*

[b] *FUZE Solutions, Perth, Australia*

** Email: sriram.ravisankarpadma@research.uwa.edu.au*

Abstract:

Fibre Optic Sensors (FOS) offer exceptional strain sensitivity, long-term durability and reliability for Structural Health Monitoring (SHM) of engineering structures. This study investigates the application of Fibre Bragg Grating (FBG) based FOS for bondline monitoring of hybrid Fibre Reinforced Polymer (FRP) composite and steel structures. In the hybrid composite-metallic joints, compatible adhesives are used to bond the dissimilar materials. However, bondline is the critical failure initiation point, due to its relatively lower mechanical properties. FBG sensors, with their ability to be embedded within bondline, provide a unique advantage for in-situ SHM of composite-metal interfaces. Specimens were fabricated with embedded FBGs and tested under four-point bending flexural loading. Bondline defects were introduced using embedded Teflon® sheets to simulate disbonding, enabling strain-based detection of damage progression. Digital Image Correlation (DIC) and non-destructive imaging were employed for validation. The results demonstrated that embedded FBGs were able to detect early onset of damage prior to visible failure. Also, defective specimens with bondline damage failed earlier and exhibited reduced displacement compared to the control specimens.

Bayesian service life prediction of RC bridges affected by pitting corrosion

Ali Yaghoubzadehfard[a]*, Massoud Sofi[a], Elisa Lumantarna[a], Nilupa Herath[a]

[a] *University of Melbourne, Melbourne, Australia*

** Email: ayaghoubzade@student.unimelb.edu.au*

Abstract:

Pitting corrosion presents a critical challenge for the long-term safety of reinforced concrete (RC) bridges due to its highly localised and stochastic nature. This study develops a probabilistic framework for predicting the remaining service life of RC structures by integrating First-Order Reliability Method (FORM), Second-Order Reliability Method (SORM), and Bayesian Markov Chain Monte Carlo (MCMC). Two case studies are explored: a laboratory-scale RC beam with experimentally induced corrosion, and a 1960s highway bridge in China assessed using in-situ load–deflection data. In the beam case, probabilistic modelling of pitting severity using a Gumbel distribution revealed that localised pit clustering reduced the estimated service life by up to 5 years compared to baseline models, with mean failure time decreasing from 62 to 83 years. For the real bridge, MCMC-based Bayesian updating with observations from Years 40 and 47 led to sharper posterior degradation predictions, particularly in effective stiffness, which dropped to 62% of its initial value by Year 150, compared to 80% in the prior model. Moreover, reliability indices fell below the target value of $\beta = 4.3$ after 73 years, highlighting the structural implications of time-dependent deterioration. The results underscore the importance of integrating Bayesian updating with field data and modelling spatial variability in corrosion severity. The proposed framework improves long-term forecasting and supports data-informed maintenance decisions for ageing RC bridges.

Experimental study of transversely loaded fillet welds for seismic actions

Shahab Ramhormozian[a*], Mark Zhang[a], Charles Clifton[b], Michail Karpenko[c], Hafez Taheri[c], Zhan Chen[a], Pingsha Dong[d]

[a] *Auckland University of Technology, Auckland, New Zealand*

[b] *University of Auckland, Auckland, New Zealand*

[c] *HERA, Auckland, New Zealand*

[d] *University of Michigan, Ann Arbor, USA*

** Email: shahab.ramhormozian@aut.ac.nz*

Abstract:

The New Zealand Steel Structures Standard NZS3404 uses a simplified method to predict the design capacity of fillet welds and hence to size the weld. From current research into the performance of these fillet welds under transverse and longitudinal loading to failure, the current weld design provisions are likely to be conservative compared with those in overseas high seismically active countries of comparable technical capability in fabrication. This paper describes a research project to identify the actual capacity of the fillet welds, as the most common type of welds, by experimental cyclic testing, to propose more realistic design provisions for fillet welds in seismic resisting systems compared to those specified by NZS3404. This is a collaboration between AUT, UoA, HERA and the University of Michigan, with the aim of making the seismic fillet welds design and fabrication more cost-effective while ensuring the continuing adequate performance of these welds, particularly under severe seismic actions. The experimental cyclic testing is being conducted at AUT labs. These include fillet weld samples of different sizes being loaded cyclically in the elastic and post-elastic range using dynamic hydraulic actuators. This paper, which has also been presented in the 2024 NZSEE and 2024 STESSA Conferences, provides information about the test setup, specimens' configurations, and cyclic loading regime along with the results and recommendations.

Effect of stiffening on stress concentration factor in spatial YY tubular joints

Weiqiang Wang[a*], Yifan Gao[b], Ben He[b], Jiaze Shi[a]

[a] *Hohai University, Nanjing, China*

[b] *PowerChina Huadong Engineering Corporation Limited, Hangzhou, China*

** Email: weiqiang.wang@hhu.edu.cn*

Abstract:

In jacket foundations, tubular joints constitute structural weak points prone to stress concentration due to their complex geometric characteristics. This study employs ANSYS/LS-DYNA to establish a numerical model for spatial YY tubular joints, systematically investigating the distribution patterns of Stress Concentration Factor (SCF) under axial load, in-plane bending (IPB) load, and out-of-plane bending (OPB) load. To mitigate stress concentration at tubular joints, a stiffening ring reinforcement method is proposed. Through parametric analysis, the influence mechanisms of stiffening ring quantity and dimensions on SCF are elucidated. Results demonstrate that under individual loading conditions (axial load, IPB load and OPB load), SCF exhibits approximately symmetric distributions between 0°-180° and 180°-360° intervals, with local variations attributed to stress interactions among multi-planar braces under external loads. The reinforcement solution significantly improves stress concentration behavior. This research provides valuable insights for optimizing spatial tubular joints.

Enhanced interaction equations for the accurate design of CFS channels subjected to combined compression and bending

Seyed Mohammad Mojtabaei[a*], Maryam Hasanali[b], Iman Hajirasouliha[c]

[a] *Loughborough University, Leicestershire, United Kingdom*

[b] *University of Auckland, Auckland, New Zealand*

[c] *University of Sheffield, Sheffield, United Kingdom*

** Email: m.mojtabaei@lboro.ac.uk*

Abstract:

The presented study aims to develop optimised interaction equations for more accurate design of cold-formed steel (CFS) lipped channel beam-columns under combined compressive load and bending about both major- and minor-axes, aligned with the Direct Strength Method (DSM). Experimentally validated finite element (FE) models of CFS elements were developed in ABAQUS software, accounting for material nonlinearity and geometric imperfections. The validated models were then used to conduct a parametric study to assess the structural performance of over 500 CFS elements with various element lengths, thicknesses, and cross-sectional geometry under various load eccentricities. The results were then used to assess the efficiency of the simplified linear interaction equation prescribed by the Australian/New Zealand Standard (AS/NZS-4600) and American Iron and Steel Institute (AISI-S100), as well as the extended DSM, in predicting the capacity of CFS lipped channel beam-column elements. The analysis revealed that existing interaction equations, on average, may lead to an approximately 30% error in estimating the strength of CFS beam-column members. Following a reliability analysis, a new interaction expression was developed with optimised parameters, in which different exponent parameters were proposed for minor- and major-axes bending. The results demonstrated a considerable improvement in the accuracy of the beam-column strength predictions compared to the existing methods.

Vibration Properties of a Steel Building with Friction Sliding System

Gholamreza Hashemi[a*], Shahab Ramhormozian[a], Sherif Beskhyroun[a], Zhenduo Yan[a], G. Charles Clifton[b], Gregory A. MacRae[c], Liang-Jiu Jia[d,e], Rajesh Dhakal[c], Pierre Quenneville[b], Geoffrey Rodgers[c], Ping Xiang[e], Xianzhong Zhao[d,e]

[a] *Auckland University of Technology, Auckland, New Zealand*

[b] *University of Auckland, Auckland, New Zealand*

[c] *University of Canterbury, Christchurch, New Zealand*

[d] *State Key Laboratory of Disaster Reduction in Civil Engineering, Shanghai, China*

[e] *Tongji University, Shanghai, China*

** Email: gholamreza.hashemi@autuni.ac.nz*

Abstract:

This paper presents the vibration characterization of a near-full-scale three-story steel-framed structure, referred to as the ROBUST building, featuring composite floors and multifunctional seismic-resistant systems. This structure was tested on the large shake table array at the International Joint Research Laboratory of Earthquake Engineering (ILEE) facilities in late 2023 and early 2024.The research utilizes a MATLAB-based system identification toolbox that implements various modal analysis techniques. These techniques include three frequency domain-based methods (Peak Picking, Frequency Domain Decomposition, and Enhanced Frequency Domain Decomposition) as well as a time-domain approach (Stochastic Subspace Identification). The building was assessed in two configurations—one with Non-Skeletal Elements (commonly known as Non-Structural Elements-NSEs) and one without—to evaluate their impact on the structural dynamic properties. The results reveal significant differences in modal parameters between the two configurations, emphasizing the substantial contribution of non-structural elements to the building's dynamic behavior. This study offers insights into the accuracy and applicability of various system identification techniques developed for both experimental input-output and operational output-only modal analysis of structures. The findings deepen the understanding of the role that non-structural elements play in building vibration characteristics and affirm the effectiveness of system identification methods for structural characterization. Portions of this paper were presented at the 2025 NZSEE Annual Conference, detailing the test setup, configurations, and applied earthquake records, along with the results and recommendations.

Novel thermal barrier coatings with polymer-derived ceramic interlayers for jet engine critical components

Andrzej Nowotnik[a]*

[a] *Rzeszow University of Technology, Rzeszow, Poland*

** Email: nowotnik@prz.edu.pl*

Abstract:

This study demonstrates an advanced route to enhance the high-temperature capabilities of TiAl alloys used in low-pressure turbine blades, aiming to match service conditions typically confined to Ni-based superalloys. A polymer-derived ceramic (PDC) interlayer based on SiAlOC serves both as a corrosion-resistant bond coat and a robust substrate for a ceramic top coat. The PDC layers, synthesized via a sol-gel route and deposited by dip-coating or spray-coating, underwent two-stage thermal treatment (drying and pyrolysis). XRD, FTIR, and SEM/EDS confirmed dense, amorphous SiAlOC films (700–800 nm) with strong adhesion. Adjusting the pyrolysis protocol facilitated a stable interfacial oxide ("layer Z"), enhancing thermodynamic stability. Subsequently, a 7YSZ (ZrO_2-Y_2O_3) top coat was deposited using EB-PVD combined with hollow-cathode plasma activation. By optimizing beam power, substrate temperature (850–950 °C), and chamber pressure, columnar ceramic layers with excellent adhesion were consistently formed. Process parameter modifications—especially temperature and plasma current—improved coating growth, interfacial bonding, and TBC durability at elevated temperatures. Comprehensive testing verified the effectiveness of these TBC systems. Isothermal and cyclic oxidation at 950 °C showed high oxidation resistance and minimal mass gain in the thermally grown oxide. Measurements of thermal diffusivity, nanoindentation, erosion resistance confirmed the coating's ability to lower the substrate temperature, preserve mechanical integrity, and resist delamination under aggressive turbine conditions. These findings highlight the potential of polymer-derived ceramic interlayers for advanced TBC architectures, paving the way for extended operational envelopes of TiAl-based components in modern jet engines.

Refined nonlinear flexibility-based model for fire performance assessment of RC and composite members

Cosmin-Gruia Chiorean[a]*

[a] *Technical University of Cluj-Napoca, Cluj-Napoca, Romania*

** Email: cosmin.chiorean@mecon.utcluj.ro*

Abstract:

This paper presents an advanced computational method for the analysis of structural members exposed to fire, based on a novel second-order flexibility-based fiber beam-column element. Developed using the complementary strain energy approach in combination with the Engesser-Crotti theorem, the formulation rigorously accounts for both geometric and material nonlinearities-including the interaction between biaxial bending moments and axial forces, thermal elongation, and slenderness effects. Specifically developed for RC and composite steel-concrete members, the model accurately captures their unique material properties and interaction effects in fire conditions. The second-order flexibility-based formulation, employing the Finite Analytic Method (FAM) for numerical integration, provides a comprehensive framework for integrating both material (distributed plasticity) and geometrical nonlinearities using a single element per member. The nonlinear analysis framework supports both isothermal analysis for generating strength interaction diagrams and an-isothermal analysis for predicting fire resistance time under progressive heating. By enabling the generation of interaction diagrams for slender columns under combined axial force and biaxial bending at elevated temperatures, the method fills a key gap in current research. These diagrams are essential for reliably assessing combined axial load and biaxial bending effects, especially when thermal degradation and stability significantly influence structural behavior. Validation through benchmark problems and a set of preliminary comparative studies demonstrates the accuracy and computational efficiency of the proposed method, providing an initial but robust foundation for performance-based fire design and serving as a benchmark for future, more extensive parametric and sensitivity studies on complex coupled thermal, material, and geometric nonlinearities.

A novel technique of fire protection of externally bonded FRP laminate: use of vermiculite mortar plaster along with moisture barrier coating

Khaja Kamal Fayaz Ahmed[a]*, Premkumar N[a], Anil Agarwal[a]

[a] *IIT Hyderabad, Hyderabad, India*

** Email: ce22resch11003@iith.ac.in*

Abstract:

Reinforced concrete (RC) members are often strengthened by externally bonding Fiber Reinforced Polymer (FRP) laminates to improve their strength and stiffness. However, while carbon fibers remain thermally stable up to 400–500°C, the polymer matrix weakens significantly at elevated temperatures, especially above its glass transition temperature (Tg), reducing the bond and stiffness during a fire event. Although fireproofing mortar is an effective way to delay temperature rise, it is less effective in the initial phases due to convection from moisture evaporation within the mortar. This study proposes a technique to improve fire resistance by adding a moisture barrier coating between vermiculite mortar layers. This approach helps delay the flow of heat toward the FRP, thereby extending the time before it reaches its Tg value. A detailed experimental study was conducted by exposing RC members to fire with and without a moisture barrier placed within vermiculite mortar of 30 mm and 45 mm thickness. The performance was evaluated by measuring the temperature at the CFRP substrate-interface during the fire. According to ACI 440.2R-17, the Tg for most epoxy resins falls between 60°C and 82°C; therefore, 60°C was used as a comparison limit. The results show that adding a moisture barrier delayed the temperature from reaching 60°C by more than 20 minutes for 30 mm thick vermiculite mortar and by over 35 minutes for 45 mm thick vermiculite mortar. This study guides the selection of effective vermiculite mortar thickness with a moisture barrier coating to fire protection.

Elevated temperature thermal properties of foam concrete for fire resistant walls

Branavan Arulmoly[a]*, Anthony Ariyanayagam[a], Mahen Mahendran[a]

[a] *Queensland University of Technology, Brisbane, Australia*

* *Email: branavan.arulmoly@hdr.qut.edu.au*

Abstract:

Foam concrete (FC) is emerging as an innovative material due to its superior thermal insulation properties. Its distinctive cellular structure not only minimizes heat transfer but also contributes to lightweight nature, making it suitable for various construction applications. Despite these advantages, FC's fire resistance capabilities remain largely unexplored due to limited knowledge about its thermal behaviour under high temperatures representative of real fires. This study aims to evaluate key thermal properties of FC such as thermal mass, specific heat capacity, thermal expansion, residual strength, and fire resistance level (FRL) when subjected to elevated temperatures. FC samples were produced using a pre-formed foam method, utilizing a natural foaming agent. Target dry densities ranged from 800 to 1800 kg/m³, achieved by varying both the type and proportion of fine aggregates (river sand and pumice sand). When heated from 25 to 1200 °C, all FC types experienced thermal mass loss due to phase transitions in the cement matrix and aggregate materials yet retained approximately 75–80% of their original mass. Endothermic reactions observed during these transitions suggest improved fire resistance through increased heat absorption. FCs containing pumice sand exhibited greater thermal expansion compared to those with river sand. After exposure to 1000 °C, residual strength tests showed that FCs maintained considerable compressive strength. In standardized ISO 834 fire tests lasting 45 min, pumice sand-based and river sand-based FCs demonstrated FRLs of 30 and 15 min. The findings serve as a basis for experimental fire testing and numerical modelling of foam concrete walls.

Hybrid fibre reinforced magnesium oxychloride cement-based composites: A fire-resistant solution for cladding applications

Farhan Ahmad[a*], S. Rawat[b], Richard (Chunhui)[a], Lihai Zhang[c], Y.X. Zhang[a,b]

[a] *Western Sydney University, Sydney, Australia*

[b] *University of Technology Sydney, Sydney, Australia*

[c] *University of Melbourne, Melbourne, Australia*

** Email: f.ahmad@westernsydney.edu.au*

Abstract:

Magnesium oxychloride cement (MOC) has emerged as a sustainable and viable alternative to ordinary Portland cement (OPC), gaining attention for its use in cladding applications due to its inherent fire resistance. Recent advancements in fibre-reinforced MOC composites (FRMOCC), incorporating fibres such as basalt (BaF), polypropylene (PP), and polyethylene (PE), have shown potential for improving mechanical strength and ductility. However, their fire resistance and thermal degradation mechanisms require further investigation. This study investigates the elevated temperature performance of hybrid FRMOCC modified with ground granulated blast-furnace slag (GGBS). The influence of varying heating rates on spalling behaviour was also assessed. Results showed that hybrid FRMOCC with 0.3-0.5% PP, 1% PE, and 0.5-0.7% BaF significantly improved spalling and cracking resistance while maintaining structural integrity. In contrast, composites with 1.25% PE and 0.75% BaF experienced explosive spalling under high thermal exposure (ISO fire curve). Overall, hybrid FRMOCC (S1PE0.5B0.5PP and S1PE0.7B0.3PP) were found suitable for non-structural cladding applications, where enhanced fire resistance, spalling resistance, and fire suppression are critical. Microstructural and thermal analyses, including scanning electron microscopy (SEM), thermogravimetric analysis (TG), and differential scanning calorimetry (DSC), were conducted to elucidate the underlying thermal degradation mechanism.

Future perspectives in building: The role of connections in view of a consilient approach

Giovanni Muciaccia[a]*

[a] *Politecnico di Milano, Milano, Italy*

** Email: giovanni.muciaccia@polimi.it*

Abstract:

Continuous growth of population and economy is increasing pressure on natural resources to the point that effects on climate change are evident. Given the high contribution to carbon dioxide emissions of the construction industry, education, research, and consulting communities should promote retrofitting of existing buildings rather than building new ones. Connections between existing and new members play a key role. They are required to behave consistently with the main structure in terms of forces and displacements and are often crucial in determining the limits of the overall structural behaviour. Current design models for such connections were developed addressing specific design issues and typically related to load-bearing capacity only. The paper identifies weaknesses in the definition of performance requirements for connections in current design codes, highlighting the need for a new holistic approach in the future.

Effect of head-to-shank ratio on concrete-cone capacity of cast-in headed fasteners

Tilak Pokharel[a,b*], Jessey Lee[a], Anita Amirsardari[a], Emad Gad[a]

[a] *Swinburne University of Technology, Melbourne, Australia*

[b] *Australian Engineered Fasteners and Anchors Council (AEFAC), Melbourne, Australia*

* *Email: tilakpokharel@swin.edu.au*

Abstract:

Cast-in-headed fasteners are commonly used in precast and cast-in-situ construction. However, these fasteners remain outside the design scope of AS 5216:2021. While AS 3850 addresses their use for temporary lifting, permanent anchorage is governed only by proprietary data. This study develops and validates a two-dimensional axisymmetric finite-element (FE) model to isolate the effect of head size on tensile capacity. A systematic parametric investigation covering head-to-shank diameter ratio (d_o/d_i) ranging from 2.0 to 4.5 demonstrates that the tensile capacity increases compared to the concrete cone capacity (CCD) prediction. At d_o/d_i higher than 3.5, the edge-distance requirement of 1.5 times the embedment depth of the fastener is inadequate.

Assessing the durability of timber-steel hybrid continuous connections through accelerated aging tests

Abdulaziz Abdulmalik[a]*, Benoit Gilbert[a], Hong Guan[a], Tuan Ngo[b], Alex Remennikov[c]

[a] *Griffith University, Gold coast, Australia*

[b] *University of Melbourne, Melbourne, Australia*

[c] *University of Wollongong, Wollongong, Australia*

* *Email: abdulaziz.abdulmalik@griffithuni.edu.au*

Abstract:

Steel–timber hybrid structural systems offer a promising approach for enhancing the bending strength, stiffness and ductility of Engineered Wood Products while supporting sustainable construction practices. To form these systems, steel elements must be connected along the timber length. While short-term performance of such connections has been studied, long-term durability, especially with adhesives, remains underexplored. This study evaluates the durability of two steel-timber continuous connections formed by embedding a steel plate into Laminated Veneer Lumber, either by bonding it with polyurethane adhesive or fastening it with 14G screws. Two accelerated ageing protocols were used and compared against unaged nominally identical specimens. The first protocol applied a modified ASTM D1037 wet-dry cycle method, initially developed to assess wood-based panels under severe moisture fluctuations. The second used a humidity-temperature cycle simulating more realistic long-term conditions. The samples were then destructively tested in shear. Adhesive bonded specimens exposed to the ASTM-based method exhibited complete bond failure before destructive testing, while those subjected to humidity-temperature cycling retained only 33% of the unaged shear capacity, with failure developing at the adhesive interface, despite unaged specimens failing in the timber. In contrast, screwed connections retained about 60% and 95% of their original shear capacity under the ASTM-based and humidity–temperature cycles, respectively. These findings highlight the role of mechanical fasteners in ensuring long-term performance and suggest that although adhesives are key to achieving composite action, their durability can be significantly reduced by environmental exposure.

Proposed carbonation-induced corrosion investigation of precast concrete grout tube connections

Arif Ullah[a]*, Scott J Menegon[a], Jessey Lee[a]

[a] *Swinburne University of Technology, Melbourne, Australia*

** Email: arifullah@swin.edu.au*

Abstract:

Cast-in-headed fasteners are commonly used in precast and cast-in-situ construction. However, these fasteners remain outside the design scope of AS 5216:2021. While AS 3850 addresses their use for temporary lifting, permanent anchorage is governed only by proprietary data. This study develops and validates a two-dimensional axisymmetric finite-element (FE) model to isolate the effect of head size on tensile capacity. A systematic parametric investigation covering head-to-shank diameter ratio (d_o/d_i) ranging from 2.0 to 4.5 demonstrates that the tensile capacity increases compared to the concrete cone capacity (CCD) prediction. At d_o/d_i higher than 3.5, the edge-distance requirement of 1.5 times the embedment depth of the fastener is inadequate.

Development of fire test set-up for Fasteners in Australia

Ishani Lankadhikara[a]*, Tilak Pokharel[a,b], Jessey Lee[a,b], Anita Amirsardari[a], Emad Gad[a]

[a] *Swinburne University of Technology, Melbourne, Australia*

[b] *Australian Engineered Fasteners and Anchors Council (AEFAC), Melbourne, Australia*

** Email: ilankadhikararajapak@swin.edu.au*

Abstract:

The performance of fastening systems embedded in concrete is critical to the structural integrity and safety of buildings during fire events. While design standards increasingly incorporate fire resistance as a requirement, experimental data on the performance of fasteners under fire in both normal and sustainable concrete types remain limited. In Australia, the prequalification and design of fasteners are governed by AS 5216. However, it does not currently address the performance of fasteners under fire exposure. Consequently, there is a growing reliance on international guidelines primarily from Europe for evaluating fastener behaviour in elevated temperature conditions. This paper presents the development of fire test setup designed to evaluate the tensile performance of fasteners in normal and low-carbon concretes under elevated temperature. The setup replicates ISO 834-1 fire conditions and allows for simultaneous mechanical loading and real-time thermal measurement. This framework serves as a benchmark for future experimental research and provides essential data to support performance-based design, refine numerical simulations, and contribute to the development of fire-resistant fastening systems and improved design guidelines.

Potential for developing alkali activated glass-based foam using waste PV glass

Ailar Hajimohammadi[a*], Ayesha Siddika[a]

[a] *University of New South Wales, Sydney, Australia*

** Email: ailar.hm@unsw.edu.au*

Abstract:

The rapid expansion of photovoltaic (PV) technologies has led to a growing volume of end-of-life PV glass, requiring sustainable recycling strategies. One promising avenue is incorporating waste PV glass into alkali-activated materials (AAMs) for construction applications. PV glass contains silicon and aluminium contaminants, which, under alkaline conditions, induce foaming reactions in AAM. This phenomenon presents a unique opportunity to develop lightweight foam with tailored porosity. However, this has not been explored in the current literature. Therefore, this study aims to investigate the potential of PV glass precursors for producing lightweight AAMs and alkali-activated glass-based foams (AGFs). This research explores how varying PV glass content and activator silica modulus affect foaming expansion, density, and compressive strength. Results show that increasing PV glass content from 50 to 80wt% enhances volume expansion due to foaming reaction by silicon and aluminium contaminants. Lowering the silica modulus further promotes expansion by creating a more alkaline environment and accelerating foaming reactions. Additionally, while higher PV glass content reduces density, moderate strength (≈15 MPa at 28 days) can still be achieved, especially in mixes with balanced activator composition. Foam specimens made with 100% PV glass demonstrate very low densities (~0.72 g/cm^3) and moderate strength (~0.6 MPa). However, uncontrolled foaming can compromise mechanical performance, limiting practical applications. Overall, the findings highlight the self-foaming capability of PV glass and its suitability for sustainable, lightweight AAMs and foams. Further optimisation of mix design and curing protocols is recommended to improve pore control and mechanical performance for practical applications.

Use of rice straw biochar as alternative SCM to fly ash

Ailar Hajimohammadi[a]***, Han Gao[a], Ayesha Siddika[a], Lim Jhuin Fhung[a], Basil Ben[b]

[a] *University of New South Wales, Sydney, Australia*

[b] *Transport for New South Wales, Sydney, Australia*

* *Email: ailar.hm@unsw.edu.au*

Abstract:

The increasing demand for ordinary Portland cement (OPC) poses significant environmental challenges, particularly due to its high carbon footprint. Supplementary cementitious materials (SCMs), such as fly ash, an industrial byproduct, have been widely used to partially replace OPC, with successful replacement levels reaching up to 40%. However, the availability of fly ash is declining due to the gradual phasing out of coal-fired power plants. In response, biochar derived from pyrolysis of biomass has recently emerged as a promising alternative SCM. Yet, its broader application is hindered by its relatively low pozzolanic reactivity, which limits its potential at high replacement levels. This study explores the performance of rice straw-derived biochar, selected for its high silica content, as SCM at high cement replacement ratio up to 40%. The results demonstrate that this silica-rich biochar can significantly achieve comparable or even superior compressive strength to OPC mortar with same cement replacement ratio by fly ash (up to 40%). While a reduction in initial flowability was observed, the comparable mechanical strengths highlight the potential of using biochar as viable SCM. These findings support the development of sustainable SCMs and position silica rich biochar as a promising alternative to conventional SCM such as fly ash.

Thermal conductivity in low-carbon mortar and concrete using supervised machine learning algorithms

Yanni Bouras[a]*, Le Li[a]

[a] *Victoria University, Melbourne, Australia*

** Email: yanni.bouras@vu.edu.au*

Abstract:

Cement-based materials provide strong insulation due to their low thermal conductivity which is important for building energy efficiency. To reduce the embodied carbon of ordinary Portland cement (OPC), supplementary cementitious materials (SCMs) such as fly ash are being increasingly used. However, SCMs can alter physical, mechanical, and thermal properties. This paper employs supervised machine-learning algorithms to develop models to accurately predict thermal conductivity of mortar and concrete containing high-volumes of SCMs. Artificial neural networks, linear regression, ensemble regression trees and Gaussian process regression were all considered. The machine-learning models were trained using 215 data points where 70% of the dataset was utilised for training and 30% for model verification. The results demonstrate that machine-learning models can accurately predict thermal conductivity of mortar and concrete materials. Furthermore, a Shapley additive explanation (SHaP) analysis was conducted that analysed the importance of each input variable on prediction of thermal conductivity.

Implementing sense 600® to reduce embodied carbon in reinforced concrete: A case study from a water infrastructure facility

Echo Wang[a*], James Grenfell[b], Giorgia Fornari[c], Siddharth Bishnoi[c], Eric Zhang[c]

[a] *NTRO, Melbourne, Australia*

[b] *NTRO, Port Melbourne, Australia*

[c] *Northwest Hub Alliance, Milsons Point, Australia*

* *Email: echo.wang@ntro.org.au*

Abstract:

This paper presents a case study on the implementation of Sense 600®, a 600 MPa reinforcing steel, in bored cast-in-situ piles for the Grit Chamber at a water infrastructure facility. Developed by InfraBuild and produced via electric arc furnace (EAF) using 100% recycled scrap steel, Sense 600® offers a higher yield strength than conventional 500 MPa reinforcement, enabling material and carbon savings without compromising structural performance. A cradle-to-gate analysis was conducted using real project data to evaluate the differences in material quantities, embodied carbon, and cost. Results show that substituting DN500 with Sense 600® led to an average 17% reduction in steel use, a 39.5% reduction in embodied carbon, and only a 6% increase in overall cost in this application. The total embodied carbon saving in the Grit Chamber piles achieved 2454.1 kg CO2-eq. The Odour Ductwork, which includes 65 piles currently under design, is also planned to use Sense 600® with designers confirming suitability for these structures. The total embodied carbon saving across the project will be reported once complete data becomes available. These findings support the broader adoption of Sense 600® as a viable low-carbon alternative for reinforced concrete construction.

Evaluation of Delithiated Beta Spodumene (DBS) as a supplementary cementitious material

<u>Mohammed Fouad Alnahhal[a*]</u>, Basil Ben[b], Ailar Hajimohammadi[a]

[a] *University of New South Wales, Sydney, Australia*

[b] *Transport for New South Wales, Parramatta, Australia*

** Email: m.alnahhal@unsw.edu.au*

Abstract:

The increasing production of lithium compounds in Australia, driven by demand for electric vehicle and energy storage applications, has led to the accumulation of significant volumes of delithiated beta spodumene (DBS), a by-product of lithium extraction. This study investigates the potential of DBS as a supplementary cementitious material (SCM) by evaluating its pozzolanic reactivity relative to conventional SCMs, namely Class F fly ash and ground granulated blast furnace slag (GGBFS). The reactivity was assessed using Rietveld X-ray diffraction (XRD) to quantify the amorphous content, isothermal calorimetry, and strength activity index. The DBS exhibited a substantial amorphous phase content (58.1%), moderate exothermic response indicative of pozzolanic reactivity, and enhanced strength development over time. At 20% volumetric replacement, the 28-day SAI of DBS was 79%, satisfying ASTM C618 requirements and exceeding the performance of fly ash (75%). These results suggest that DBS offers viable potential as a sustainable SCM, promoting both industrial waste valorisation and reductions in the environmental impact associated with cement production.

Analysis of industrial steel storage pallet racks to assess sensitivity to progressive collapse

Elide Nastri[a*], Rosario Montuori[b], Massimiliano Ferraioli[c], Marco Simoncelli[d], Marina Pastore[a]

[a] *Department of Civil Engineering, Fisciano, Italy*

[b] *Department of Pharmacy, Fisciano, Italy*

[c] *Department of Engineering, Caserta, Italy*

[d] *Politecnico of Milan, Milan, Italy*

** Email: enastri@unisa.it*

Abstract:

Steel pallet racking systems, which are essential components of modern logistics infrastructure, are critically vulnerable to progressive collapse triggered by the failure of individual structural elements. Despite the potentially severe consequences, current design codes and regulatory frameworks do not include explicit provisions addressing this failure mode or establishing performance-based safety criteria. This study adopts a column removal methodology to examine the progressive collapse behaviour of commercially available industrial steel pallet racks in their standard manufacturer configurations. The results reveal a marked susceptibility to disproportionate collapse following the removal of both end and interior columns. These findings offer a fundamental basis for advancing structural understanding and for developing improved design guidelines aimed at mitigating progressive collapse risks in steel pallet racking systems.

Optimisation of welded structures, minimising cost and harmful environmental effects

Károly Jármai[a]*

[a] *Universiy of Miskolc, Miskolc, Hungary*

** Email: karoly.jarmai@uni-miskolc.hu*

Abstract:

The paper aims to show how to calculate the cost of a welded structure. How to formulate the optimisation model on a local level and a global level approach. In the local approach, we consider the material and several fabrication costs, like welding, cutting, surface cleaning, and painting, that directly affect the structural sizes. In the global approach, we consider the environmental impacts of welding gases. We can determine the effect of the different welding and cutting technologies on the structure using the optimisation method, the generalised reduced gradient technique. We can determine the minimum mass or cost while all design requirements are fulfilled.

Design recommendation for bolted circular hollow section flange-plate connections

Ian G. Kennedy[a]*, Jeffrey A. Packer[a], Kyle Tousignant[b]

[a] *University of Toronto, Toronto, Canada*

[b] *Dalhousie University, Halifax, Canada*

* *Email: i.kennedy@mail.utoronto.ca*

Abstract:

Recent nominal strength expressions for bolted circular hollow section flange-plate connections under axial tension, flexure, and combined loading are initially reviewed. Recommended amendments are then presented for the tension and bending models that achieve improved statistical parameters. These are verified through a comparison of predicted capacities and experimental/numerical test results. The interaction of tension and bending is finally assessed using an optimisation procedure to determine the most suitable interaction curve, which is then extended to the tension plus bi-axial bending load case.

Investigation of compression and tension capacity of mono helix piles in cohesive soils

Biju Balakrishnan[a]*, Pat Rajeeev[a], Aruna Karunarathne[a], Emad Gad[a]

[a] *Swinburne University of Technology, Melbourne, Australia*

** Email: bbalakrishnan@swin.edu.au*

Abstract:

Expansive soils pose significant challenges for lightweight structures globally resulting in billions of dollars in damages to asset owners. In Australia, the millennium drought (1997-2010) and subsequent El Nino event (2012-2016) caused severe damage to many houses built on expansive soil. According to the Victorian Buildings Authority, 5.3% of dwellings constructed during this period in the Western Suburbs of Melbourne have exhibited significant slab heave issues. These reports highlight the substantial losses incurred by homeowners due to climatic variations, which is expected to worsen in the future due to more frequent extreme climate conditions. It is increasingly recognised that an alternative footing system tied to the stable ground with tension piles (helical anchors) would provide a solution. This system would provide confinement for the excessive heave movements and a better alternative to traditional stiffened raft footing in highly reactive soil. The capacity of helical anchors to resist tension, compression and deflection under various depths is necessary to assess the suitability of the proposed footing system. However, there is very limited research on such anchoring parameters in reactive soils in Australia. This study investigates the tension and compression capacity and vertical deflection of helical anchors in clay soil under various depths. Twenty-four test piles at various depths are installed at a test pad at Koo Wee Rup, Victoria, Australia, and field testing is carried out to measure both tension and compression capacity. Installation torque is also measured, and a correlation is established between torque, compression and tension capacities.

Material modelling for cold-formed steels

Lahiru N. Dissanayake[a*], Fiona Walport[b], Xiang Yun[c], Leroy Gardner[a]

[a] *Imperial College London, London, United Kingdom*

[b] *University College London, London, United Kingdom*

** Email: l.dissanayake23@imperial.ac.uk*

Abstract:

The definition of accurate stress-strain models is essential for facilitating design by advanced structural analysis. The constitutive behaviour of steels is influenced by various factors, including its chemical composition, manufacturing processes and heat treatment methods. To date, a wide range of stress-strain models has been developed for cold-formed normal and high-strength steel, each differing in complexity, range of applicability and accuracy. This paper reviews the existing stress-strain models and builds upon previous research by compiling the most extensive database to date, which includes over 1603 experimentally derived stress-strain curves for cold-formed steel materials drawn from the global literature, encompassing a diverse range of steel grades, thicknesses and cross-section types. This paper analyses existing predictive expressions for the key material parameters based on the wider dataset collected and proposes some modifications where necessary. Overall, the proposed models enhance the understanding and predictive accuracy of stress-strain curves for structural steels, which are essential for facilitating the growing use of advanced computational methods in the analysis and design of steel structures.

Integrated carbon emission assessment of lightweight ultra-high-performance concrete for MiC high-rise buildings from material to building

Hailong Ye[a]*, Zushi Tian[a]

[a] *The University of Hong Kong, Hong Kong, China*

** Email: hlye@hku.hk*

Abstract:

Modular integrated construction (MiC) is transforming the construction industry by enhancing productivity, safety, and sustainability. This study delved into the potential of incorporating artificial lightweight aggregates made from recycled glass into the production of lightweight, high-strength, low-carbon, and thermally insulating structural concrete, i.e., lightweight ultra-high-performance concrete (UHPC) and lightweight C60 concrete. Their impact on both the embodied and operational carbon emissions of MiC high-rise residential buildings was investigated, in which the integrated analysis of material-structure-building interactions was emphasized. The results indicate that, for lightweight UHPC, the increased unit volume carbon emissions could be offset by its extended service life and reduced material consumption, resulting in slightly lower embodied carbon emissions compared with traditional C60 concrete. The integrated analysis revealed that the use of lightweight C60 concrete could reduce total carbon emissions by 5.4%, while lightweight UHPC could achieve a 6.2% reduction due to its longer building lifespan and superior insulation properties.

Effect of surfactant type on foam film stability in alkali-activated materials

Xiufen Yang[a]*, Hailong Ye[a]

[a] *The University of Hong Kong, Hong Kong, China*

* *Email: xiufeny@connect.hku.hk*

Abstract:

Foam instability in alkali-activated materials remains a fundamental challenge that limits the development of low-carbon lightweight foam concrete with sufficient strength and thermal insulation performance. By examining the interfacial behavior of four typical surfactants - anionic (SDS, 40K), cationic (CTAB), and nonionic (Triton X-100) - the research explores their effects on stability -and adsorption on alkali-activated slag (AAS). Results reveal that foam film stability at the air-liquid interface critically influences pore uniformity and connectivity, thereby affecting overall performance. SDS and 40K exhibit poor film retention due to strong adsorption, while Triton X-100's stability is limited by coordination with multivalent cations. Conversely, CTAB forms resilient foam films in alkaline conditions, effectively maintaining pore structure during setting of AAS matrix.

Ultra-low carbon alkali-activated slag using carbon-captured sodium carbonate activator

Junhan Liu[a]*, Hailong Ye[a]

[a] *The University of Hong Kong, Hong Kong, China*

** Email: ljh1030@connect.hku.hk*

Abstract:

The ordinary Portland cement (OPC) industry contributes approximately 7% of the global anthropogenic CO_2 emissions, necessitating innovative decarbonization strategies beyond adopting conventional supplementary cementitious materials (SCMs). This study develops ultra-low carbon alkali-activated slag (AAS) binders using carbon-captured sodium carbonate activator, which is synthesized through injecting simulated cement flue gas into sodium aluminate solution, yielding sodium carbonate hydrates and aluminum hydroxide in the activator. Compared with the conventional AAS prepared using reagent-grade sodium carbonate activator, the developed AAS binder demonstrates a 46% reduction in carbon footprint—equivalent to just 4% of that of OPC counterparts—while achieving 60% and 71% higher compressive strength at 28d and 56d, respectively, matching the reference OPC performance.

Mitigation of alkali-silica reaction in waste glass-based hybrid alkaline mortar

Aida Rahmani[a*], Zhong Tao[a], Soheil Jahandari[a], Tariq Aziz[b], Utsab Katwal[a]

[a] *Western Sydney University, Penrith, Australia*

[b] *Charles Sturt University, Bathurst, Australia*

** Email: 19539225@student.westernsydney.edu.au*

Abstract:

The reuse of waste glass in construction offers sustainability benefits but faces challenges due to alkali-silica reaction (ASR) induced durability issues. This study investigates the mitigation of ASR in hybrid alkaline mortars that incorporate over 80% waste glass by utilising calcium aluminate cement (CAC) and polydimethylsiloxane (PDMS). Mortar specimens were assessed for flowability, compressive strength, water absorption, water contact angle, and ASR expansion. Results indicate that CAC enhances early-age strength and effectively reduces ASR, while PDMS significantly improves hydrophobicity, reduces water absorption by 77%, and suppresses ASR expansion to just 0.06%. These findings support the use of CAC and PDMS as effective strategies for developing durable and sustainable waste glass-based mortars.

Exploring baghouse dust as a reactive component in alkali-activated mortars

Ahmed Mahmoud Alnahhal[a]*, Taehwan Kim[a], Ailar Hajimohammadi[a]

[a] *University of New South Wales, Sydney, Australia*

* *Email: a.alnahhal@unsw.edu.au*

Abstract:

Industrial activities such Construction and demolition have resulted in increased the amount of contaminated soil residue. The thermal treatment of contaminated soil is one of the soil remediation techniques. During this process, baghouse dust (BHD) is collected as a waste material. This work demonstrated the potential of BHD as a precursor for alkali-activated materials and the effect of Na_2O to binder ratio on the mechanical performance and the setting time. Fly ash (FA) and Ground granulated blast-furnace slag (GGBFS) were utilised in conjunction with BHD as precursor mixtures. In all mixtures, 50% GGBFS was maintained, while the remaining precursor comprised of FA and BHD; with FA being substituted by 50% BHD to assess the impact of BHD on the performance of alkali-activated mortars. Compressive strength, setting time and microstructure development were evaluated. The findings indicated that the performance of the BHD mixture was comparable to that of the FA mixture, while the compressive strength of the 50:50 GGBFS:FA and 50:50 GGBFS:BHD mixtures were in range of 37 – 46 MPa and the setting time was found to be in range of 5 – 12 hours.

Bridge construction risks in complex environments - A hybrid analytic hierarchy process and optimised neural network model

Miao Li[a]*, Yongli Liu[b], Mingyang Xi[b], Huajun Bo[c], Henglin Xiao[b], Qiang Ma[b], Md Geaur Rahman[d]

[a] *Charles Sturt University, Bathurst, Australia*

[b] *Hubei University of Technology, Wuhan, China*

[c] *4China Railway Siyuan Survey and Design Group Co., LTD, Wuhan, China*

[d] *Charles Sturt University, Port Macquarie, Australia*

** Email: mli@csu.edu.au*

Abstract:

A model was developed to predict construction risks for bridges by coupling the analytic hierarchy process (AHP) with an optimised Extreme Learning Machine (ELM) neural network method. Firstly, by using the AHP method, 22 factors were proposed to comprehensively represent risks during bridge constructions. These factors were formulated in a two-level hierarchical structure. Secondly, a scientific and rigorous risk assessment system was formulated. Thirdly, an ELM neural network model was built to automate the risk prediction process and minimise the subjectivity associated with the traditional expert assessment system. The ELM model was optimised by the Sparrow Search Algorithm (SSA). Finally, the AHP-SSA-ELM model was tested on 50 bridge construction cases and showed a 96% agreement with the expert assessment. This means that the proposed model can be used confidently to assess risks during bridge construction in complex environments. The model is accurate, practical, and efficient. It will inform risk management to avoid social and economic losses during bridge constructions.

An investigation of causal relationships between intensity measures and rocking response via interpretable machine learning

Stefan Chu[a]*, Anastasios Giouvanidis[b], Cheng Ning Loong[a], Elias Dimitrakopoulos[a]

[a] *The Hong Kong University of Science and Technology, Kowloon, Hong Kong*

[b] *University of Auckland, Auckland, New Zealand*

* *Email: kwschu@connect.ust.hk*

Abstract:

Rocking motion is an intriguing mechanism that allows structures such as monuments, critical contents, etc. to uplift and pivot during an earthquake, providing sufficient stability to avoid collapse. However, rocking dynamics that governs their seismic stability is nonlinear, discontinuous, and stochastic, posing a challenging problem that has been studied for decades. While performance-based earthquake engineering has identified key intensity measures (IMs) for predicting rocking response under realistic base excitations, understanding their causal relationships with rocking behaviour offers deeper insights into the underlying physics. This study leverages recent advances in interpretable machine learning (ML), specifically Shapley Additive Explanations (SHAP) and Partial Dependence Plots (PDP), to explore these causal relationships for rigid blocks subjected to recorded earthquakes. In particular, it uses SHAP dependence plots in tandem with PDP to visualise specific interaction ranges between a combination of IMs and rocking response. These interpretable ML methods provide clear, physics-driven interpretations of complex nonlinear rocking dynamics, minimising reliance on "black box" ML models.

Experiment-aided virtual modelling framework for elastoplastic analysis of auxetic honeycombs with stochastic mechanical properties

Yuhang Tian[a*], Yuan Feng[a], Wei Gao[a]

[a] *University of New South Wales, Sydney, Australia*

** Email: yuhang.tian@student.unsw.edu.au*

Abstract:

Because of the exceptional capabilities in shock isolation and energy absorption, auxetic honeycombs are envisioned as promising bracing structures for biomedical implants like artificial vertebrae. To assess their suitability for robust engineering applications, the elastoplastic behaviours of auxetic honeycombs under compressive loading is evaluated with consideration of fabrication-induced uncertainties. To this end, an experiment-aided virtual modelling framework is proposed to enhance the quality of uncertainty sources for the present simulation-based uncertainty quantification, thereby achieving a more credible stochastic assessment. Apart from the repeated experiments dedicated to uncertainty data collection, all available experiment observations serve as the reference for assessing the posterior probability density of the unknown parameters through the Bayesian inverse uncertainty quantification (UQ) module. The proposed framework consists of three main components, where initially a pre-virtual model (PRVM) is formulated thorough normalising flow-based uncertainty analysis, followed by the implement of Bayesian inference to propagate the experiment observations backwards to ascertain the uncertain parameters. Then, an advanced multidimensional slice sampling method is developed to deal with the derived complex posterior probability density function (PDF) of mechanical parameters. Consequently, the refined uncertainty parameters enable the post-virtual models (POVMs) which incorporate user-customised experiments, leading to reliable stochastic assessment results. Relying on the developed framework, the stochastic profiles of some key indicators such as negative Poisson's ratio in elastic phase and structural yield load capacity are characterised to demonstrate the structural performance under service conditions.

Machine learning modelling for mechanical properties prediction and multi-objective optimization of eco-friendly rubberized concrete

Ming Yu[a*], Yang Yu[a], Ailar Hajimohammadi[a]

[a] *University of New South Wales, Sydney, Australia*

** Email: ming.yu3@student.unsw.edu.au*

Abstract:

This study focuses on the application of machine learning methodology for predicting the mechanical properties and optimizing the mixture of rubberized concrete to enhance and highlight its eco-friendly characteristics. Algorithms such as Linear Regression Models, Efficiently Trained Linear Regression Models, Regression Trees, Support Vector Machines (SVM), Gaussian Process Regression Models (GPR), Kernel Approximation Regression Models, Ensembles of Trees and Neural Networks will be adapted to predict the mechanical properties of rubberized concrete, while the NSGA-II will be used for optimization of mixture. The data inventory for training models includes 1034 data sets derived from the 55 experimental studies of rubberized concrete. The data sets will be divided into two segments in this study to ensure reliability and dependability. 70% of the data is used for sieving out the optimum algorithms, while the remaining 30% will be applied for the test procedure. After that, the NSGA-II is carried out to optimize the rubberized concrete mixture portion. As eco-friendly characteristics are commonly emphasized in rubberized concrete research, this study aims to optimize the concrete mixture and evaluate the CO_2 emission and energy consumption of rubberized concrete composed of 10 constituent materials. These findings demonstrate the effectiveness and advantages of machine learning techniques in property prediction and mixture optimization of rubberized concrete materials.

Bridging the gap: Machine learning literacy among Indonesian construction stakeholders

Angga Trisna Yudhistira[a*], Mirza Mahendra[b], Tantri Nastiti Handayani[a], Arif Ridho[a], Nandhita Noorviana Puspita Dewi[a], Ayumna Uzlifati[a]

[a] *Universitas Gadjah Mada, Sleman, Indonesia*

[b] *PT PP (Persero) Tbk, Jakarta, Indonesia*

** Email: angga.trisna.y@mail.ugm.ac.id*

Abstract:

Artificial intelligence (AI) in the construction industry has become a novel innovation that is developing in many institutions. Machine learning (ML) is a part of AI, which has a vital role in making predictions, optimization, and decision-making. A lot of research has proved that ML utilization in construction has given many benefits in terms of cost, time, carbon emission reductions, increasing safety levels, etc. However, the machine learning adaptation and comprehension in developing countries like Indonesia are still low. This study aims to observe the understanding level of construction stakeholders in Indonesia regarding ML utilization. Questionnaires have been given to 55 respondents in various institutions, including regulators (government), project owners, contractors, consultants, and academics. The result shows that 40.0% of respondents express that they only have a little knowledge regarding ML. Even so, 89.1% of respondents declare that ML is relevant to the construction industry. Most of the respondents also state that the lack of knowledge and competence of personnel becomes the most important challenge of adapting ML in construction. Thus, higher exposure regarding ML is needed for construction industry stakeholders. Competency development is also needed for personnel and students in construction disciplines regarding operating ML-based systems so that the optimized construction product will be obtained.

Recycled plastics as modified binders for road construction

Jai Goundar[a]*

[a] *The University of the South Pacific, Suva, Fiji*

** Email: goundar.jai@gmail.com*

Abstract:

Roads are crucial for connecting communities, facilitating economic activity, and fostering social development; a well-established road network is essential for any country. The interaction of rainfall with asphalt pavement can cause the pavement's structure to deteriorate and eventually create potholes. There is a rising interest in using recycled and repurposed plastic waste in road construction to reduce the deterioration of roadways. Thus, engineers are looking into environmentally friendly ways to use plastics to build long-lasting road infrastructure. The traditional road material mix is partially substituted with shredded waste plastic bottles to increase mechanical properties. Bitumen is modified with shredded plastic waste to create a mixture that may be utilized as the top layer of roadways and exhibit good binding qualities, strength, and water resistance. This can be considered as an efficient binder for bitumen to tolerate higher temperatures and lessen crack formation and seepage. From the stability test conducted for Asphalt/Plastic mix, the production mix with a 6.5% bitumen content and 5% of shredded dyed recycled plastic would provide the best performance to withstand shear and the most significant impact from traffic loads. Samples with 5% of dyed shredded plastic bottles performed better in the three-point bending test and could take a load up to 790 N.

Compressive strength of concrete bricks with recycled crumbed rubber

Sarkar Noor E Khuda[a*], Jay Sul[b], Arun Doppalapudi[b]

[a] *Central Queensland University, Melbourne, Australia*

[b] *Central Queensland University, Mackay, Australia*

** Email: s.noorekhuda@cqu.edu.au*

Abstract:

Scrap tire waste disposal has become one of the major environmental challenges in Australia. In response to this issue, researchers have explored the use of discarded rubber as a partial replacement for natural aggregates in concrete production, particularly for concrete. Incorporating scrap tire rubber into concrete bricks offers several advantages, including reduced density, enhanced toughness and ductility, improved impact resistance, and more effective thermal and acoustic insulation. In this study, concrete bricks were then cast by partially replacing sand with rubber particles at varying volume percentages (0%, 2.5%, 5%, 7.5%, 10%, and 12.5%). All bricks were cured for 7 and 28 days, followed by mechanical testing to evaluate their compressive strength. All specimens were cast and tested as per the relevant Australian standard. The test results show that the compressive strength of the concrete bricks gradually reduced with the increase in the amount of crumbed rubber. The compressive strength of these bricks was similar when compared to bricks commercially available in the market.

Microstructural and thermal behavior of geopolymer paste incorporating Electric Arc Furnace (EAF) slag

Kamal Kishore[a*], M. Neaz Sheikh[a], Muhammad N.S. Hadi[a]

[a] *University of Wollongong, Wollongong, Australia*

* *Email: kk007@uowmail.edu.au*

Abstract:

Geopolymer composites can be used as an alternative binder with the potential to reduce reliance on traditional cement to produce concrete. Geopolymer composites can be developed by activating aluminosilicate-rich waste materials (e.g., silica fume, fly ash, ground granulated blast furnace slag, and metakaolin) using alkaline solutions. These aluminosilicate-rich waste materials can enhance the mechanical properties of geopolymer composite. Electric arc furnace (EAF) slag, a waste material rich in aluminosilicates, can be used to develop geopolymer composite, but its influence on the properties of geopolymer composite, particularly on its microstructural evolution and role in mechanical strength development, remains largely unexplored. This study examines the compressive strength, microstructural characteristics, phase evolution, and thermal stability of EAF slag-based geopolymer paste. The geopolymer paste was prepared with 10–30 wt.% EAF slag as a partial replacement for ground granulated blast furnace slag (GGBS). Experimental results indicate that EAF slag enhances the structural and microstructural properties of the geopolymer paste. Compressive strength testing confirmed that incorporating up to 20 wt.% EAF slag yields optimal performance, achieving a compressive strength of 56.0 MPa with improved microstructural characteristics and reduced porosity. The TGA results showed that the control mix without EAF slag exhibited the highest weight loss, whereas the mix with 30 wt.% EAF slag demonstrated superior thermal stability at elevated temperatures. The SEM analysis confirmed a dense microstructure due to enhanced geopolymerization, while FTIR analysis indicated strong aluminosilicate bonding. These findings highlight the potential of EAF slag for high-temperature and sustainable construction applications.

Structural performance of railway sleepers reinforced with aqua-thermally treated crumb rubber aggregates and recycled tire steel fibers

B.G.V Sanjaya[a,b*], S Venkatesan[a], J.M.R.S Appuhamy[b], W.M.K.R.T.W Bandara[b], R.J Gravina[a,c]

[a] *RMIT University, Melbourne, Australia*

[b] *University of Ruhuna, Galle, Sri Lanka*

[c] *The University of Queensland, Brisbane, Australia*

** Email: s3959393@student.rmit.edu.au*

Abstract:

The growing intensity of rail traffic, axle load, and operational speed imposes increased structural demand on concrete sleepers. Despite their widespread use, the lower tensile performance of concrete often results in cracking in railway sleepers under service loads. Such failures critically undermine their structural integrity and service life. This study examines the railway sleeper performance improvements by integrating rubber aggerates and steel fibres sourced from end-of-life tires. Conventional rubber incorporation typically leads to reductions in concrete strength. As a result, this study introduces an innovative aqua-thermal treatment to modify the surface texture of rubber particles. This formation strengthens the rubber/cement bonding, enabling significant compressive strength recovery. Integrating recycled tire steel fibres further elevates the strength of rubberized concrete, exceeding that of ordinary concrete. Furthermore, synergistic effect of rubber and steel fibres enhances the post-cracking behaviour, limiting crack propagation and growth. These advances confirm the material's suitability for railway sleepers, exhibiting substantial increases in load-bearing capacity at the first crack and ultimate failure. Besides, steel fibres in concrete significantly reduce the extent and severity of cracking. The enhanced impact resistance also reinforces the railway sleeper's structural integrity under sudden impact and dynamic loads. The observed performance gains are primarily attributed to the strong rubber/cement interfacial bonding through the proposed treatment, along with the crack-bridging mechanism provided by the steel fibres. These findings validate the efficacy of recycled tire steel fibre-reinforced rubberized concrete as a durable and reliable material for railway sleepers operating under elevated axle loads and high-speed conditions.

Influence of steel fibre shape and content on ultra-high-performance alkali-activated concrete

Muhammad Hadi[a]*

[a] *University of Wollongong, Wollongong, Australia*

* *Email: mhadi@uow.edu.au*

Abstract:

Ultra-high-performance alkali-activated concrete (UHPAC) can be used as an environmentally friendly replacement to Ordinary Portland Cement concrete (OPC). However, the development of microcracks in UHPAC is mainly attributed to its high brittleness, which negatively affects its engineering properties. This study investigates the influence of straight, corrugated and hooked-end steel fibres, incorporated at volume fractions of 1%, 2%, and 3%, on the engineering properties of ambient-cured UHPAC. The engineering properties investigated included flowability, compressive strength, splitting tensile strength, direct tensile strength and modulus of rupture. The test results showed that the flowability of UHPAC mixes decreased with increasing fibre volume fraction. Conversely, significant improvements in the mechanical properties of UHPAC were observed. The compressive strength, splitting tensile strength, direct tensile strength and modulus of rupture of UHPAC mixes increased as the steel fibre content increased. The addition of 3% hooked-end fibres resulted in increases of 9.8% in compressive strength, 129.3% in splitting tensile strength, 36.5% in direct tensile strength, and 103.5% in modulus of rupture compared with the reference mix. The results demonstrated that incorporating hooked-end fibres into UHPAC enhanced its mechanical performance, making it suitable for advanced structural applications that require high compressive and tensile strength.

Microstructural and thermal behavior of geopolymer paste incorporating Electric Arc Furnace (EAF) slag

Vito Lokito[a*], Elisa Lumantarna[a], Massoud Sofi[a]

[a] *University of Melbourne, Melbourne, Australia*

* *Email: vlokito@student.unimelb.edu.au*

Abstract:

The growing demand of steel fibre reinforced concrete elements have motivated the development of recycled steel fibres (RSF), mainly due to their cost and environmental advantages. However, various research has suggested that RSF sourced from waste metallic sources such as waste tyres and industrial byproducts often possess considerable geometrical and mechanical property variabilities. This undeniably caused doubts on the mechanical performance consistency and variability of RSF-reinforced concrete (RSFRC) elements, slowing their widespread adoption. This study conducts a finite element analysis-based analyses of the pullout behaviour RSF in normal and high-performance concrete matrices, with the aim to capture the influence of RSF heterogeneities on its pullout performance. The proposed numerical modelling approach was observed to be able to replicate the experimental pullout results obtained from RSFs recovered from decommissioned oil and gas facilities. The findings indicate that the ultimate pullout strength of RSF is strongly controlled by the effective RSF width and ultimate tensile strength, particularly in determining the occurrence of fibre rupture or concrete spalling failure modes. A minimum threshold for effective width and tensile strength was identified to be crucial in preventing fibre rupture failure modes, with the specific values varying according to the concrete strength being used. The insight received from the study could be further developed as performance safety factors of RSFRC, RSF production guidelines, as well as a starting point for the development of a multiscale numerical model.

Enhancing mechanical and durability properties of concrete using recycled PET fibres

S.M.D.V. Suraweera[a,b*], Chamila Gunasekara[a], David W. Law[a], Sudhira De Silva[b], Champika Ellawala[b], Sujeewa Setunge[a]

[a] *RMIT University, Melbourne, Australia*

[b] *University of Ruhuna, Galle, Sri Lanka*

* *Email: s3957793@student.rmit.edu.au*

Abstract:

The widespread use of Polyethylene Terephthalate (PET) has led to critical environmental issues due to its low recycling rate and accumulation in landfills and oceans. As a sustainable solution, this study focuses on the use of recycled PET fibres in concrete to improve both mechanical and durability performance. Concrete specimens with 2.5% volume fraction of 40 mm recycled PET fibres were tested against control samples for compression, tension, flexure, water permeability, and surface electrical resistance. Compressive, splitting tensile, and flexural strengths of the fibre-reinforced concrete increased by 4%, 10%, and 7.5%, respectively. Durability performance significantly increased by reduction in water permeability (from 38.8 to 20.3 mm) and increase in surface electrical resistivity (from 22.3 to 29.0 kΩ·cm), indicating a denser, less permeable matrix due to strong fibre–matrix bonding and reduced microcrack formation. Therefore, it is evident that, recycled PET fibres offer a promising dual benefit of plastic waste mitigation and improved concrete properties for sustainable construction applications.

Experimental study of thermal properties of textile fibre-reinforced mortar

K.A.P Wijesinghe[a,b*], Chamila Gunasekara[a], David W. Law[a], Gamini Lanarolle[b], Hidallana Gamage H.D[b]

[a] *RMIT University, Melbourne, Australia*

[b] *University of Moratuwa, Katubedda, Sri Lanka*

** Email: s3855403@student.rmit.edu.au*

Abstract:

The increasing environmental impact of textile waste has driven research into innovative reuse strategies, including the incorporation in construction materials. This study investigates thermal properties of cement mortars reinforced with textile fibers: cotton, polyester, nylon, and elastane. Mortars were prepared with fibre volume fractions of 0.25%, 0.5%, and 1.0%, and fiber lengths of 6 mm, 12 mm, and 18 mm. After 28 days of curing, their thermal conductivity and resistivity were measured using Transient Line Source meter, while pore structure was characterized through CT imaging. Results indicated that all fiber-reinforced mortars improved thermal resistivity compared to the control, with the elastane-reinforced sample showing the highest resistivity, 2.5 times that of the control, with no textile. Micro-CT analysis revealed increased porosity and larger, interconnected pores in the elastane sample, contributing to disrupted heat flow and enhanced thermal resistance. These results demonstrate the potential of textile waste for sustainable thermal insulation in construction.

Evaluation of high-strength shear connector design in AS/NZS 2327:2017 and AS/NZS 5100.6:2017

Yifan Zhou[a*], Zhichao Huang[b], Riti Shrestha[a]

[a] *The University of Western Australia, Crawley, Australia*

[b] *Indara Digital Infrastructure, Sydney, Australia*

** Email: yifan.zhou@uwa.edu.au*

Abstract:

The capacity design of shear connectors is critical to achieving sufficient composite action in steel–concrete composite beams. While AS/NZS 2327:2017 and AS/NZS 5100.6:2017 provide established design provisions, their applicability is limited to shear connectors with diameters less than 25 mm and material strengths below 500 MPa. These limitations pose challenges for large-scale structures such as suspended warehouse floors and long-span composite bridges, where larger and higher-strength shear connectors are often required. In response, this paper presents a new design method developed to address these scenarios, extending the applicability beyond the current standard. A comprehensive database of 333 experimental push-out tests from the existing publications has been compiled, encompassing both bolted connectors and welded studs with a wide range of connector sizes, materials, and configurations. The results demonstrate that the new method offers significantly improved accuracy and consistency, particularly for large and high-strength connectors. The study highlights the need to revise existing code provisions and provides practical recommendations for the design of shear connectors in large-scale composite structures.

Tensile test of post-installed screw anchors in thin uncracked steel fibre-reinforced concrete

Lieu Thai Ng[a]*, Daniel Ting Wee Looi[a,b], Jessey Lee[c], Adeline Ling Ying Ng[a], SS Ajeesh[d]

[a] *Swinburne University of Technology, Kuching, Malaysia*

[b] *Sunway University, Petaling Jaya, Malaysia*

[c] *Swinburne University of Technology, Melbourne, Australia*

[d] *National Institute of Technology Calicut, Kozhikode, India*

** Email: lthng@swinburne.edu.my*

Abstract:

Screw anchors are a type of post-installed mechanical anchor that transfer load to concrete through multiple screw anchor threads that cut into the wall of the drilled hole during installation. Screw anchors are widely used in concrete connections due to their ease of installation and high load-bearing capacity. As the industry advances toward net-zero carbon emissions, steel fibre-reinforced concrete (SFRC) can be an enabler to reduce cement-based concrete by adopting thinner structural members in buildings and tunnel applications such as hollow-core slabs, walls in modular buildings, and tunnel lining walls. However, the design of screw anchors in SFRC is currently not addressed in the current design codes. Hence, this paper presents an experimental study of single anchors embedded in thin uncracked SFRC panels (i.e., 100 mm thickness) subject to tensile loading. The ultimate failure loads and observed failure modes of the screw anchors are presented. The experimental results are compared to the predicted strength in Eurocodes EN 1992-4:2018.

Development of seismic test setup for fasteners in high-strength concrete

Prayush Rajbhandari[a]*

[a] *Swinburne University of Technology, Melbourne, Australia*

* *Email: prajbhandari@swin.edu.au*

Abstract:

This study developed a seismic test setup to evaluate the performance of post-installed fasteners in high-strength concrete. The test setup included a vertically mounted 5 MN actuator to generate controlled crack widths on the concrete specimen and a horizontally mounted 100 kN actuator to apply tensile loads on the fastener. A specially designed test specimen with a bow-tie crack inducer was used to ensure controlled crack propagation without interfering with fastener failure mechanisms. An M16 expansion fastener with an effective embedment depth of 86 mm, prequalified for C2 seismic performance category, was tested under the C2.5 loading protocol, which involves varying crack widths and sustained tensile loads. The fastener completed all load cycles and met the required performance criteria. The average residual ultimate load was 59.5 kN, with a displacement of 1.5mm and 5.0 mm at a crack width of 0.5 mm. The coefficient of variation for both load and displacement were below 14%. The findings demonstrate that the setup is well-suited for future experimental studies on anchorage systems in high-strength concrete under seismic conditions.

Slip modulus of multi-culm bamboo members with steel bolted connections

Nahid Khodabakhshi[a]*, Elias G. Dimitrakopoulos[a]

[a] *The Hong Kong University of Science and Technology, Hong Kong, Hong Kong*

** Email: nahid.khodabakhshi@connect.ust.hk*

Abstract:

Full-culm bamboo structures commonly use members composed of two or more culms to improve strength and stiffness. A practical and widely adopted method for connecting these culms together is steel bolted connections. However, the deformation of the bolts/shear connectors during loading results in an interlayer slip, which affects the stiffness and deformation of the structure. Consequently, a key parameter in bolted connections is the slip modulus, which quantifies resistance to slip under load. The Eurocode provides an empirical slip modulus formulation for timber, based on density and bolt diameter. Previous research introduced an analytical method to characterize the elastic stiffness of bolted multi-culm bamboo axial members, effectively incorporating the dowel action of bolts during connection deformation. Therefore, this analytical method shows the potential for calculation of the slip modulus of full-culm bolted connections. Despite these advances, research on the slip modulus of full-culm bamboo remains limited. Overall, the specific aim of this study is to address this gap by focusing on the slip modulus of full-culm bamboo. It also evaluates the influence of parameters such as culm geometry, density, bolt diameter, and embedment stiffness on slip modulus magnitude.