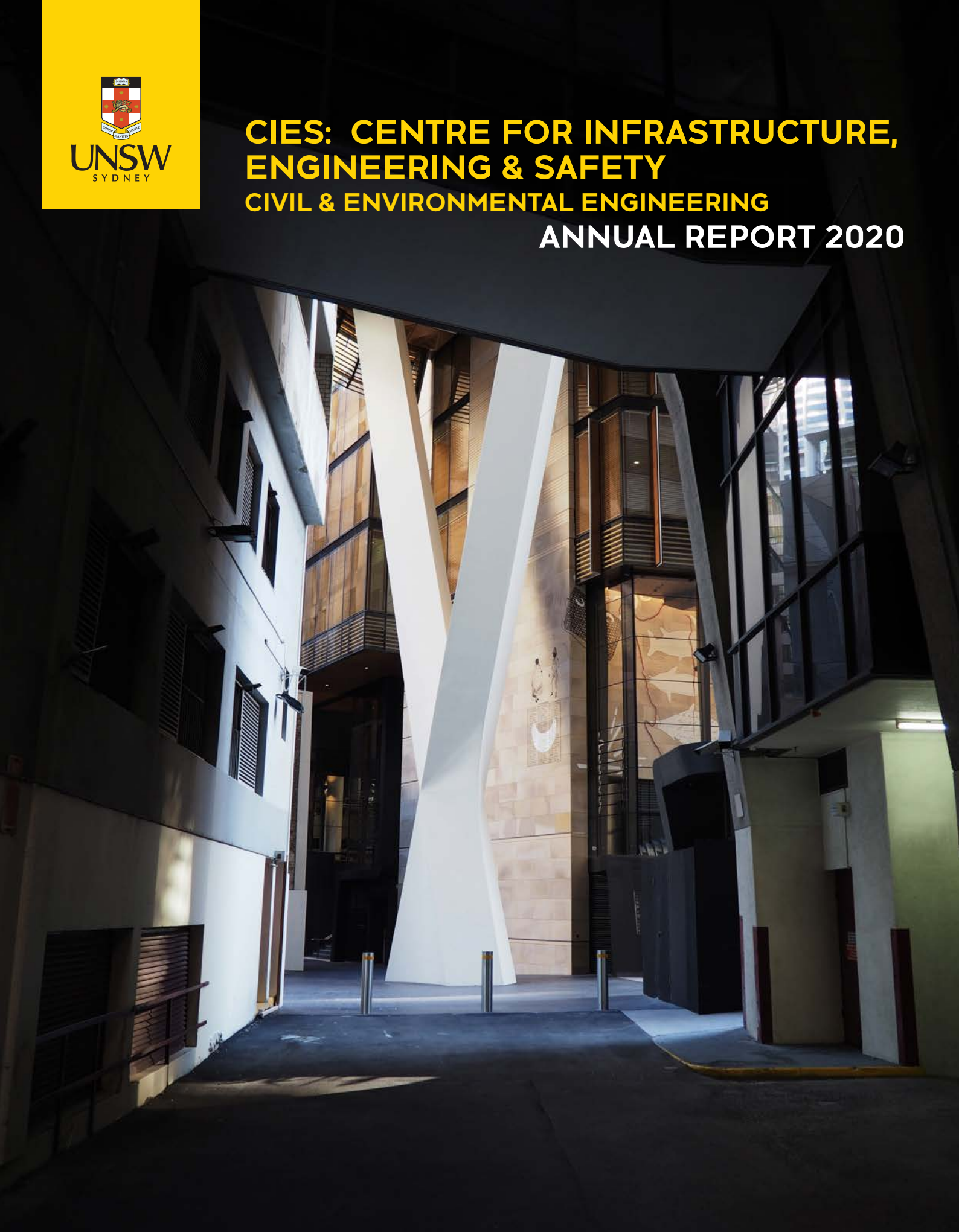
UNSW SYDNEY

CIES: CENTRE FOR INFRASTRUCTURE, ENGINEERING & SAFETY

CIVIL & ENVIRONMENTAL ENGINEERING

ANNUAL REPORT 2020



UNSW
Centre for Infrastructure
Engineering & Safety

ADDRESS
CIES – Centre for Infrastructure, Engineering & Safety
School of Civil and Environmental Engineering (H20)
UNSW SYDNEY NSW 2052
AUSTRALIA

ENQUIRIES
Phone: (+61 2) 9385 6853
Email: cies@unsw.edu.au
Web: cies.unsw.edu.au

PROJECT & CONTENT MANAGEMENT
Mary O'Connell & Theresa Wisniewski

GRAPHIC DESIGN
Marylouise Brammer
mbrammer@bigpond.net.au
https://indd.adobe.com/view/61504118-a435-46e4-b180-67ad9c4d3608

PHOTOGRAPHY
Shutterstock
Unsplash: Marcus Lenk: Cover image and page 4-5 image
Kailash Gyawali: page 38-39 image
UNSW Engineering: Kate Brown, Mike Gal, Kurt Douglas

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SECTION 1

OUR CENTRE

OUR VISION

Our vision is to be the leading internationally recognised research centre in the region, for investigating, understanding and predicting the safety and behaviour of engineering infrastructure under in-service and limit conditions.
We achieve this as an integral part of a circular economy, dedicated to high societal productivity and minimised waste.

We aim to be the nexus of the various scientific disciplines in the broad fields of engineering infrastructure; its design, evaluation, construction, performance, retrofit and reuse.

ABOUT US

WE CONDUCT PURE AND APPLIED RESEARCH

CIES was established as a University of New South Wales Research Centre in January 2007 to facilitate advanced research in all aspects of civil engineering infrastructure, embodying building structures, bridges, tunnels, roads, railways, pavements, dams, and the like. It has expanded to include construction management, advanced systems, and low-carbon technologies.

THE CORE activities of the Infrastructure Centre are underpinned by a significant number of eminent academic staff of international renown in their respective fields, particularly in structural engineering, geotechnical engineering, construction management, advanced materials engineering, pavement engineering, engineering mechanics, computational mechanics and in laboratory testing.

We conduct pure and applied research with funding won from National Competitive Grant Programs (particularly through the Australian Research Council's Discovery and Linkage Project Schemes) as well as other contestable funding programs, and with direct support from industry. We also undertake commercial activity in collaboration with industry that is challenging and strategic in its nature. These research and commercial activities are conducted with essential physical resources, such as those of the Heavy Structures Research Laboratory, Advanced Materials Research Laboratory, Geotechnical Laboratory, and our Advanced Computational Analysis Laboratory.

The composite of structural, geotechnical, construction and materials academics and researchers in the Infrastructure Centre is the leading group in Australia and in the region, with a demonstrated capability for delivery of research outcomes.

Ideally located at UNSW Sydney's School of Civil and Environmental Engineering, CIES projects incorporate several engineering disciplines – from structural engineering to geotechnical engineering to construction and management, and engineering materials to computational mechanics.

MULTI-DISCIPLINARY COLLABORATION FOR THE BEST RESULTS

At CIES, we apply our skills to engineering and safety assessments of infrastructure. In particular, we look at the construction and risk management of buildings, bridges, dams, roads and other infrastructure when subjected to both in-service conditions and overload (or limit) conditions, such as in fire, earthquake, cyclone or blast situations, or when exposed to hostile environments and climatic variations.

The Centre aims to promote multi-disciplinary collaboration across the Faculties of Engineering, Science and the Built Environment at UNSW and to foster international and interdisciplinary research collaborations and partnerships with industry.

IN SHORT, CIES OFFERS:

- World-class interdisciplinary research by a team made up of structural and geotechnical engineers and scientists, and advanced systems and management personnel engaged in construction planning.
- Access to advanced analytical, computational and experimental techniques and facilities.
- A forum for idea exchange and research collaboration between engineers, scientists and planners.
- The ideal base from which to develop industry proposals and grant funding applications.
- Industry partnerships to secure the practical application of research outcomes.
- Opportunities for postgraduate students in a wide range of relevant disciplines."

EXECUTIVE COMMITTEE

The UNSW Centre for Infrastructure Engineering and Safety is managed by an Executive Committee comprising of the CIES Director, Research Director, Deputy Director and the Centre Manager. The committee meet on a regular basis to discuss strategy, performance and research opportunities. In addition, input to CIES management is provided by the CIES Academic Group.

Professor **CHONGMIN SONG**,
Director

Scientia Professor **MARK BRADFORD**
Research Director

Professor **ADRIAN RUSSELL**
Deputy Director Jan-Sept 2020

Professor **NASSER KHALILI,**
Deputy Director - Sept 2020 onwards

THERESA WISNIEWSKI
Centre Management

STEERING COMMITTEE

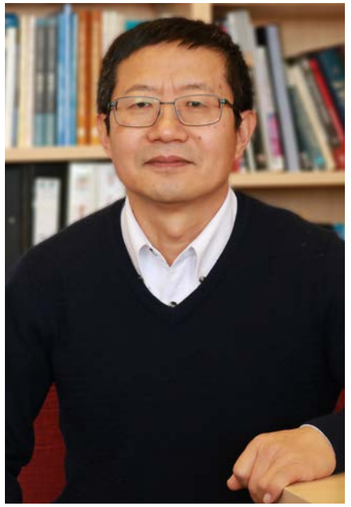
The Steering Committee meets throughout the year to oversee and monitor the progress of the Centre and to assist the Director in developing strategies to ensure that the goals and objectives of the Centre are realised. The membership of the Management Board for the Centre is:

- Professor Stephen Foster, Acting Dean, Faculty of Engineering (Chair)
- Professor Chongmin Song, CIES Director
- Scientia Professor Mark Bradford, CIES Director of Research
- Professor Adrian Russell, CIES Deputy Director
- Professor Klaus Regenauer-Lieb, School of Minerals and Energy Resources Engineering
- Scientia Professor Deo Prasad, Chief Executive Officer, CRC for Low Carbon Living
- Professor Ismet Canbulat, School of Mineral and Energy Resources Engineering
- Mrs Theresa Wisniewski, CIES Centre Manager

INDUSTRY ADVISORY COMMITTEE

The CIES is supported by an Industry Advisory Committee comprising of 12 members from industry and government organisations. The committee meet regularly with CIES academics to promote the engagement of CIES with Industry.

WELCOME



I am proud to present this annual report on our achievements at the Centre for Infrastructure Engineering and Safety (CIES) during the difficult year of 2020. The report outlines the mission of the centre, its governance structure, and profiles our staff and their achievements. It also provides an overview of projects funded by competitive national schemes and industry, our laboratories, and the publications produced by staff and students throughout 2020.

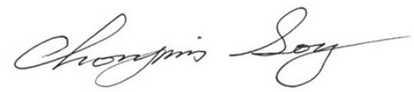
You will see an overview of our team's impressive accomplishments during 2020 within this annual report. Collectively our members secured more than $6M in research funding, graduated 11 PhD students and published 158 refereed journal papers. CIES has been very successful in the highly competitive Australian Research Council (ARC) funding schemes. Our staff were awarded two Discovery Projects, two Linkage projects, one Future Fellow and two Discovery Early Career Researcher Awards.

At the end of 2020 we farewelled two long serving academic staff, Professor David Carmichael and Associate Professor Mario Attard, both tremendous workers and achievers for the cause! We also farewelled long serving (42 years) technical services officer Tony Macken. Our best wishes to them all.

On behalf of the Executive Committee, I would like to thank all our staff and students who contributed so generously to the continuous success of the Centre in the year of the pandemic, when shutdowns and remote working became the new norm.

I would also like to express my sincere appreciation and thanks to our industry partners and advisory committee members for their strong support and contributions.

Professor Chongmin Song
CIES Director



CIES IAC INDUSTRY MEMBERS 2020

Our accomplished and dedicated Industry Advisory Committee meets regularly with CIES academics to further promote our engagement with Industry.

GARRY MOSTYN
Chair
Principal, PSM

Garry Mostyn graduated from UNSW Australia in civil engineering in 1973. He subsequently completed a master's degree in geotechnical engineering at UNSW and a bachelor's degree in geology and statistics at Macquarie University. He worked as a cadet and engineer with the NSW Department of Public Works and with consulting geotechnical engineers from 1970 until 1986. He then joined the Department of Civil Engineering at UNSW Australia where he lectured in civil and environmental engineering practice and geotechnical engineering. He joined PSM in 1997 as a Principal Consultant while retaining a part time appointment at UNSW.

Garry's fields of specialist expertise include slope engineering; foundation engineering; rock mechanics; geotechnical risk analysis; and forensic engineering. He has authored or co-authored over 80 journal and conference papers. He has worked on major projects throughout Australia and in Thailand and PNG. He has been an active member of several national and international code and practice committees and been involved at the highest levels of the Australian Geomechanics Society and the International Society for Rock Mechanics.

JAMES ALDRED
Technical Director
Concrete Future/
AECOM and Adj A/
Professor - UNSW
Civil & Environmental
Engineering

James Aldred has over 30 years' experience In the concrete industry in Australia, Asia, the Middle East and the United Kingdom. His background includes Technical Director of an international admixtures company, Manager of the High-Performance Concrete Research Group at the National University of Singapore, Technical Manager of Taywood Engineering and Honorary Research Fellow at Imperial College. He is a specialist in concrete technology including mix design, durability, investigations and advice, with a proven record of helping change industry mindset and practices. He was the Independent Verifier for the Burj Khalifa in Dubai which is the world's tallest tower.

James obtained his PhD from Curtin University. He is a Chartered Professional Engineer and a Fellow of the Institute of Engineers Australia, the American Concrete Institute and the Institute of Concrete Technology. James has received the Award of Excellence from Concrete Institute of Australia and the Award for Outstanding and Sustained Contributions to Concrete Technology by ACI International Conferences, as well as the prestigious George Stephenson Medal.

PHIL BLUNDY
Technical Director,
AECOM and
Immediate Past Chair
Engineers Australia,
Structural College
Board

Phil Blundy has nearly thirty years industry experience, at Hyder Consulting, then Cardno, and most recently at AECOM. As Technical Director at AECOM he has worked on projects for all levels of government and private agencies. Phil has been a member of Engineer Australia's Structural College Board for over ten years and is the Immediate Past Chair. He has been particularly involved in research and promotion of Australian Bridge Design Standards.

DR MURRAY CLARKE
Director, Structural Engineering APAC, Dematic, FIEAust CPEng NER APEC Engineer IntPE(Aus)

Dr Murray Clarke is Director of Structural Engineering at Dematic, a global engineering company that designs, builds and supports logistics solutions that optimise material and information flow.

After completing his PhD at the University of Sydney, Murray joined the academic staff to carry out teaching and research into steel structures, also at the University of Sydney. During this time he published widely in the field of advanced structural analysis and design of steel structures.

Murray moved to Dematic in 1999 to initiate the core discipline of structural engineering in that organisation. The main fields of Murray's current work include the design of storage racking and associated steel structures such as mezzanine floors to support Dematic's automated systems projects across the Asia Pacific region. Storage racks range in height from a few metres to more than 40 metres and make extensive use of cold-formed steel. In his current role, Murray has been fortunate to blend his academic interests with practical design and he maintains an active role in developing automated design tools for rapid and precise design of racking structures. Murray was a member of Standards Australia committee BD/62 responsible for developing AS 4084-2012 _Steel Storage Racking and is also a registered technical engineer with the European Racking Federation, a European industry body that develops design codes for the storage equipment industry in Europe.

KATHY FRANKLIN
Associate Principal- ARUP

Kathy Franklin has worked on the structural design, analysis and forensic engineering on a wide variety of building and infrastructure projects. Her particular interest and expertise is in structural dynamics (vibration, blast, impact, seismic engineering), solving such problems as design for dancing crowds in pop concerts, pedestrian bridge vibration, lively office floors, achieving low vibration environments for sensitive equipment in laboratories and hospitals, wind, vehicle and machine induced vibration of structures. Projects that she is particularly proud to have been involved with include: Singapore Sports Hub, Kurilpa Bridge Brisbane; Marina Bay Sands Skypark; Sydney Cricket Ground Victor Trumper and Noble Bradman Stands; and "The Birds Nest" Beijing National Stadium. Kathy is passionate about education of the next generation of engineers, and research that will improve delivery of future projects. She regularly guest lectures at UTS, UNSW and USyd and has participated in a number of joint industry/ academia research projects.

JIM FORBES
Chairman Australian Standard Committee BD-002

Jim Forbes is Chairman of Australian Standard committee BD-002, responsible for AS 3600, the Australian Concrete Structures Code, and represents Australia on the International Standards Organisation TC71 committee.

With over 50 years in the construction industry, Jim has been involved with the planning, design, coordination and supervision of a wide variety of civil engineering and building projects.

His expertise covers Concrete Structures, Tall Buildings, Mining, Aerospace and Transport Infrastructure. Having developed considerable experience in transport projects, he applies a unique blend of building and transport skills to public and private transport projects across Australia.

His broad experience in civil engineering has seen him involved in projects which require holistic solutions to complex engineering, transportation and planning challenges. These have typically involved major infrastructure development projects, from initial master planning to completion.

Jim has extensive experience in running multidisciplinary teams and has an enviable reputation for identifying the winning elements of Design and Construct projects.

His acknowledged expertise in concrete and concrete structures led him towards a strong involvement with the Concrete Institute of Australia and the Federation Internationale du Beton and he has served as President of each of these organisations.

SAM HENWOOD
Director Pavements and Geotechnical Transport for NSW

Sam Henwood has been practising as a geotechnical engineer since graduating from UNSW in 1994 having worked extensively in both Australia and the United Kingdom in both the private and public sectors. Since 2016, he has led the Transport for NSW (formally Roads and Maritime Services) Pavement and Geotechnical section in his current role as Director Pavements and Geotechnical.

He is responsible for 55 professional staff with 5 direct reports and manages technical risk in pavements, geotechnical engineering, geoscience and materials disciplines. Sam is the Transport for NSW representative on the Austroads Pavement Task Force, managing technical development in pavement engineering. Sam has taken a lead in the use of recycled materials in road construction.

Prior to joining Roads and Maritime Sam worked as a consultant. He was responsible for the successful completion and management of geotechnical projects and has experience of geotechnical interpretation and design, pavement design, drainage design, client liaison, resource allocation, project planning, quality control and financial accountability.

He has worked on major infrastructure projects including highways, rail and ports, residential and commercial developments, local roads and tailings dam design. He has extensive experience in the UK rail sector particularly in Scotland and northern England.

He has also spent his formative years in an earthworks testing laboratory.

PETER KEY
National Technical Development Mgr., Australian Steel Inst.

Dr Peter Key is a structural engineer with upwards of 25 years' experience in R&D, design, site supervision and project implementation in a design & construct scenario for large steel buildings. His specialties include 3D design, structural design, research & development in construction. His interests have always encompassed the use of IT to bring efficiencies to the AEC industry.

Peter is Australian Steel Institute's National Technical Development Manager and a regular presenter on steel design and construction. He is part of Standards Australia Committee BD-001 responsible for the new AS/NZS 5131 Steel structures - Fabrication and erection. He has also written a range of technical publications including the Structural steelwork fabrication and erection Code of Practice on which AS/NZS 5131 is based.

ROD MCKAY-SIM
Director, Hillside Engineering Pty Ltd
Member, Concrete Institute of Australia

Rod McKay-Sim has been involved in engineering innovation all his professional career. In the 1990s he grew a small agency based company from less than $500K turnover to a strong, profitable business of sales exceeding $30million and operations throughout Australia, New Zealand and Singapore by introducing six ground-breaking engineering technologies (now considered standard practice) in Australia and New Zealand: Since 2006 he has led his own company in innovative research and practise - professional specialties are Concrete Lifting and Anchoring Systems design and technology, Tilt-Up construction systems, and Pre-cast concrete lifting systems. Since 2003 Rod has also been a keen cyclist for charity, five times finisher in the Hartly Challenge (Canberra-Charlottes Pass-Canberra) raising money for Hartley Lifecare - helping disabled people lead happy and productive lives, and a regular in the Sydney to Surfers cycle ride, raising money for Youth Off the Streets.

JOHN MERRICK
Snr Tech Director ARCADIS Aus.Pacific
METRON - Barangaroo Stn Design Mgr

John Merrick has over 20 years' experi-ence in various types of structures including residential, commercial, retail, educational, health, recreational, stadiums and transport infrastructure in Australia and overseas. He has presented papers at engineering conferences both in Australia, United Kingdom and USA. John is a committee member on BDS - 032 - Composite Structures and BDS-01 Steel Structures.

Some of John's projects include METRON - Underground Station Design and Technical Services

(USDTS) Sydney Metro project; West Connex - Building Zone Manager - Responsible for the structural, civil and building services design for all buildings in Stage 1B including 3 ventilation stations, 6 substations, MMC office building, 2 fire pump buildings and 4 tolling buildings;. Barangaroo South -6 storey commercial and 4 storey mixed usage buildings; Australian Embassy in Kathmandu and New Delhi - detailed inspections following 2015 earthquake; Dubai Tower Doha Project manager and design engineer for 88 storey tower currently under construction; Al Harma Tower - project manager for peer review of 413m tower in Kuwait; Port of Townsville - design manager for berth expansion; Inghams Sommerville - design of new steel industrial buildings.

ANNA PARADOWSKA
Industry Engagement Manager Australian Centre for Neutron Scattering, ANSTO
Conjoint Professor in Advanced Structure Materials Syd Uni

Dr Anna Paradowska Is Industry Engagement Manager at the Australian Centre for Neutron Scattering, ANSTO as well as a conjoint Professor in Advanced Structure Materials at the University of Sydney.

Anna's current main focus is to manage the Australian Centre for Neutron Scattering -Industrial Liaison Office at ANSTO. Her vision is to promote the Centre's innovation and expertise, connecting business and industry to the Centre's ground-breaking research and modern neutron technology, to support and make a positive impact on Australian and global industry.

Her specialties include: materials characterisation, in particular neutron and synchrotron residual strain/stress measurements in various materials; and the influence of residual stress on materials performance and to relate them to design or/and manufacturing procedures as well as integrity requirements.

WARREN SOUTH
Director- Research & Tech Services at Cement Concrete & Aggregates Australia

Dr Warren South has worked in the heavy construction materials industry for the past 35 years. He started his working career in cement in 1985 with Blue Circle Southern Cement at Berrima as Assistant Works Chemist, later to become Works Chemist in 1989. During this time he worked on the development of cement and concretes specifically for high durability applications such as the immersed tube units for the Sydney Harbour Tunnel and other important infrastructure projects. As Technical Manager for NZ's Golden Bay Cement he led the development of cements specifically for use in the South Pacific, and the development of inorganic polymer binders for concrete. He gained his doctorate in Civil Engineering from the University of Wollongong in 2010, dealing with the performance of cements based on natural pozzolanic materials available in New Zealand. Warren maintains an active focus on addressing sustainability and resilience in terms of the cement and concrete industry and is a strong advocate for the positive contributions that concrete can make to the durability of the built environment.

CIES STAFF MEMBERS OF THE IAC

Professor **CHONGMIN SONG**, Director, CIES

Professor **ADRIAN RUSSELL**, Deputy Director, CIES

Professor **WEI GAO**

Associate Professor **HAMID VALIPOUR**

Scientia Professor **MARK BRADFORD** Research Director, CIES

Professor **STEPHEN FOSTER**

Professor **NASSER KHALILI**

Associate Professor **EHAB HAMED**

CIES AWARDS AND ACHIEVEMENTS 2020

In 2020 CIES researchers won over $6M in government and industry research grants, awards and fellowships, including $2.6M in the highly competitive Australian Research Council (ARC) awards.





CIES ARC Discovery and Linkage Project grants awarded in 2020.

Heartiest congratulations to CIES **Professor Mark Bradford, Professor Stephen Foster; Professor Wei Gao, Dr Ailar Hajimohammadi** and in collaboration with rCITI, **Dr David Rey** for their 2020 ARC Discovery and Linkage Project awards.

These exciting ARC projects involve:

- LEADING a paradigm shift in concrete mix design methodology, moving to a holistic approach that maximises durability of concrete alongside its mechanical performance. Industry Partner: Boral - Linkage Project LP200100531 **(Foster, Hajimohammadi, Rey)** Award $534,117 ($384,117 ARC + $150,000 industry)
- RESEARCHING the fragility and resilience of steel lattice towers - such as electricity transmission towers- to fire, Discovery Project DP210102833 **(Bradford)**, Award: $324,603, and
- ESTABLISHING a new computational design methodology to address current challenges facing creation of ultralight structures. Discovery Project DP210101353 Award $394,287 administered by UTS **(Gao)**

For further details please see Section Three of this Report.


CIES ARC DECRA Awards

Warm congratulations **Dr Souradeep Gupta** and **Dr Mehri Makki Alamdari**, for their ARC Discovery Early Career Research Awards (DECRA). These awards support Australia's next generation of researchers working in key priority areas to grow our national research and innovation capacity.

Mehri's project aims to develop a low-cost and robust bridge monitoring framework by advanced data analytics. Funding Total $430,075 2021-2023. Souradeep's research project is to develop durable biochar-foam concrete technology that enhances uptake of carbon dioxide and sulphur oxide. Funding Total $450,000, 2021-2023.

For further details please see pp38-58 Section Three of this Report.

CIES ARC Future Fellowship

Congratulations to CIES **Professor Adrian Russell** who was awarded an ARC Future Fellowship to the value of $1,040,000 for his crucial research on preventing mining disasters by improving the safety of tailings storage facilities (TSFs).

“On average” says Professor Russell, “there are two large failures a year around the world, many of which kill dozens of people and severely damage the environment by covering wide areas in tailings which are sometimes toxic.”

“My Future Fellowship will address how tailings dams liquefy, focussing mostly on liquefaction due to earthquake loading. I will consider the extreme earthquakes they are likely to experience, the extreme wetting and drying events they are likely to experience, as well as how their properties will change with age, and how engineers can use existing tools like the cone penetration test to determine their susceptibility to liquefaction.”

The anticipated outcomes from Russell’s work will be updated industry guidelines for improved design and management of TSFs, thus reducing environmental disasters and saving lives.

For further details please see Section Three of this Report.

Global leadership of Professor Stephen Foster continues

Congratulations to Professor Stephen Foster, Acting Dean of UNSW Engineering, former Director of CIES, and Head of School of Civil & Environmental Engineering 2012 – 2020, who has been elected as Vice President of the International Federation for Structural Concrete (fib).

The fib, (Fédération internationale du béton), is a not-for-profit international association formed by more than 40 national member groups and approximately 1000 corporate and individual members.

Its mission is to develop at an international level the study of scientific and practical matters capable of advancing the technical, economic, aesthetic, and environmental performance of concrete construction. The role of Vice President reflects Stephen’s long-term contribution to community on research and education.

Throughout his career Stephen has been involved in many research projects involving the use of technology in the development of concrete structures and infrastructure.

His research on Strut-and-Tie Modelling,on High Strength Concrete Columns, and Steel Fibre Reinforced Concrete, much of which was funded through ARC Discovery and Linkage project grants, now forms the basis of many of the design rules in the Australian Concrete Structures Standard, AS3600-2018. This has impact on many thousands of structures built throughout Australia each year. Similarly, his work has provided significant impact on the construction industry through incorporation in the fib Model Code 2010.

CIES NSW EPA Award

Heartiest congratulations to CIES academics **Dr Ailar Hajimohammadi, Prof Stephen Foster** and **Dr Taehwan Kim** on the NSW Environmental Protection Authority grant awarded for their geopolymer project with construction company John Holland. The grant was part of the EPA’s Civil Construction Market Program which aims to support increased re-use and recycling of construction and demolition materials in NSW civil construction projects.

Funding of $249,987 has been awarded to help develop and trial a low carbon Geopolymer Concrete (GPC) containing recycled crushed glass as a replacement for virgin sand. The project aims to unlock new markets from recycled glass in non-structural concrete in civil construction projects in NSW.

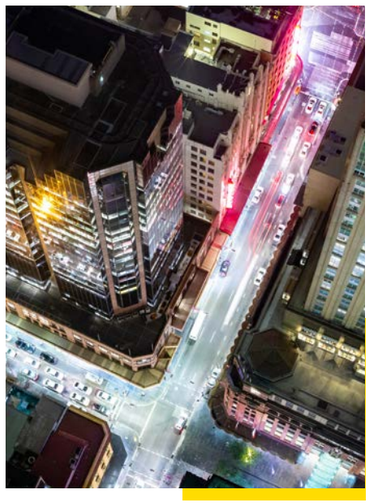
For further details please see Section Three of this Report.

Smart Infrastructure Award Dr Mehri Makki Alamdari

CIES researcher **Dr Mehri Makki Alamdari** is a winner in the Intelligent Transport Systems (ITS) Australia National Awards for 2020, in the Smart Transport Infrastructure category.

The ITS Smart Transport Infrastructure Award recognises an organisation for their technology innovation delivering excellence in transport infrastructure and network management.

Dr Alamdari’s team was one of three winners in the Smart Transport Infrastructure category, for their work on a Structural Health Monitoring System for the Sir Leo Hielscher Bridge in Brisbane.



In collaboration with Transurban, Data61 CSIRO and its research and engineering partners, UNSW, Cisco, Innovation Central Sydney and Rockfield Technologies Australia have designed and developed an advanced sensing and data platform to monitor the iconic old Sir Leo Hielscher Bridge (the Gateway Bridge) in Brisbane in real time. The platform uses machine learning techniques to detect damage before it can affect public safety.

See more at https://www.youtube.com/watch?v=ljvCLMX1zqg

And at https://www.cies.unsw.edu.au/news/congratulations-to-cies-researcher-dr-mehri-makki-alamdari

2020 Deans Award Dr Weiwei Xing

Congratulations to CIES Research Associate Dr Weiwei Xing for receiving a 2020 Dean's Award for his outstanding PhD thesis, - A Scaled Boundary Finite Element Based Node-to-node Scheme for Contact Problems, supervised by CIES Centre director Professor Chongmin Song and Emeritus Professor Francis Tin Loi.

The Dean's Award recognises the high-quality higher degree research that is carried out at UNSW and is awarded to PhD graduates who have produced a thesis that has received outstanding and/or excellent levels of achievement for all examination criteria, and in the opinion of both examiners is in the top 10% of PhD theses they have examined.

About the thesis: The analysis of contact problems is a major concern in many engineering applications. It is one of the most difficult topics due to unknown contact areas and inequality constraints. For numerical simulations, the dissimilar discretization of contact interfaces is inevitable due to the tangential slippage in large sliding contact problems. Therefore, it is impossible to maintain the node-to-node (NTN) contact.

Various treatments have been proposed to enforce the contact constraints on nonmatching contact interfaces. Their implementations, however, either fail the patch test or require sophisticated algorithms and techniques.

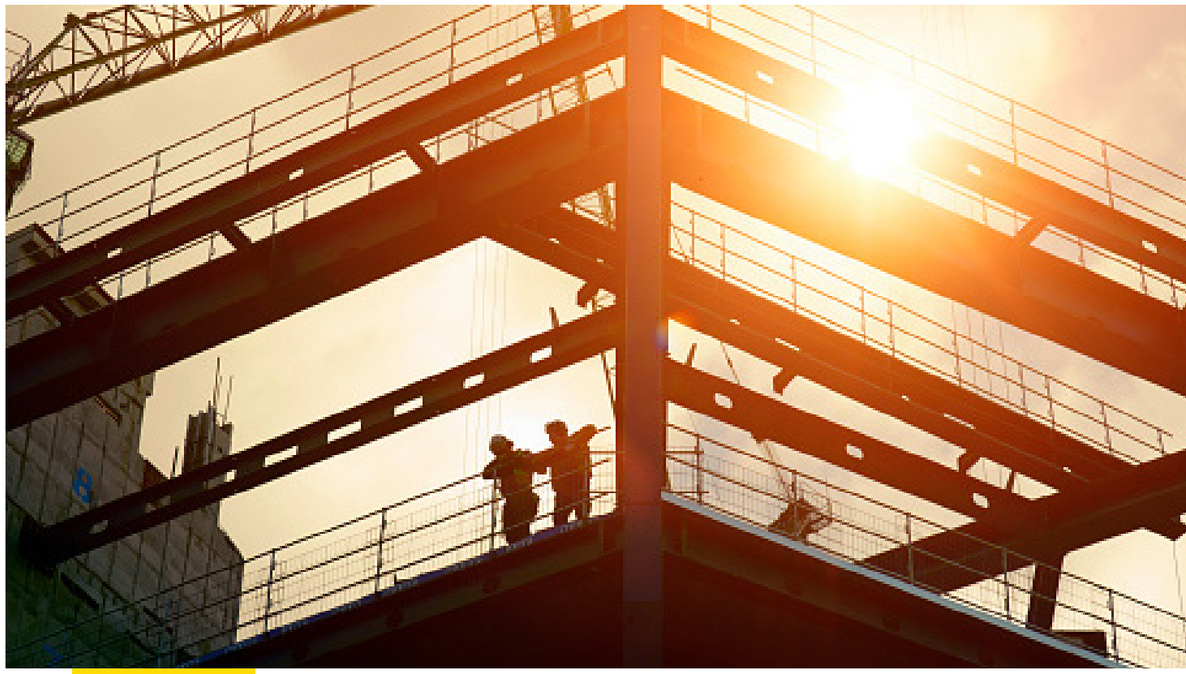
Xing's thesis presented a novel, and successful, NTN contact scheme based on the scaled boundary finite element method (SBFEM).

CIES wins CRC-P Grant

Huge congratulations to **Professor Nasser Khalili** and his team, **Dr Ailar Hajimohammadi** and **Dr Babak Shahbodagh Khan,** for their Australian Federal Government funded Cooperative Research Centre Project (CRC-P) Grant received in 2020. This joint CIES/industry project will receive $3m to convert paper and plastic landfill waste into construction materials.

In partnership with State Asphalts, Closed Loop, Primaplas and Asphaltech, our CIES researchers will work to convert mixed plastic and paper waste into value-added additives for use in asphalt. The project will aim to recover 3000 tonnes of material per year which would otherwise be exported as waste or landfilled.

For further details please see Section Three of this Report.



"Work of long-lasting value" Congratulations to David Carmichael

CIES Professor David Carmichael has been recognised for his research excellence by the academic journal Civil Engineering and Environmental Systems.

The journal, which is published by Taylor & Francis, is devoted to the advancement of systems thinking and systems techniques throughout systems engineering, environmental engineering decision-making, and engineering management, focusing in particular on the practical applications and developments of "hard" and "soft" systems techniques and thinking.

The Editors-in-Chief gave the Best Paper 2020 award for his paper 'Bias and decision making – an overview systems explanation' (Volume 37, Issue 1) along with the discussion by Professor David Elms (Volume 37, Issue 3) and Professor Carmichael's response. The award is given annually for the work that best meets the goal of the journal to publish work of long-lasting value in the study of civil engineering and environmental systems.

"Carmichael's paper develops a solid theoretical foundation for inclusion of human factors into civil engineering systems. The paper classifies and systematically analyses human subjectivity. The paper by Carmichael analyses separate issues such as prejudice, optimism, conflict of interest, confirmation bias, and more with a systems analysis of model, constraints, and objective functions."

As part of the award, the paper is made free to access for the next year.
Congratulations David!

SECTION 2

OUR PEOPLE

ACADEMIC STAFF

ATTARD, MARIO
Associate Professor Associate Head – Academic
BE PhD MHEd UNSW, MIEAust, CPEng

Research Interests: Finite Strain Isotropic & Anisotropic Hyperelastic Modelling; Anisotropic Hyperelastic Modelling of Biological Material; Plasticity Formulation for Confined Concrete Columns; Cover Spalling in High Strength Reinforced Concrete Columns; Lateral Buckling of Thin-Walled Beams.Active focus on addressing sustainability and resilience in terms of the cement and concrete industry and is a strong advocate for the positive contributions that concrete can make to the durability of the built environment.

ATROSHCHENKO, ELENA
Senior Lecturer
MSc in Mechanics and Applied Mathematics, Saint-Petersburg State University
PhD in Civil Engineering, University of Waterloo, Ontario

Research Interests: Lie in the area of Computational Mechanics and Numerical Methods, with application to fracture mechanics, acoustics, bending and vibration of composite plates.

BIDARMAGHZ, ASAL
Lecturer
PhD Civil Engineering (Geothermal Technologies) University of Melbourne

Research Interests: Energy geo-structures and geothermal systems, Investigating the impacts of urbanization on subsurface temperature increase at the city-scale, Uncertainty analysis of large scale subsurface hydro-thermal models.

BRADFORD, MARK
UNSW Scientia Professor
BSc BE PhD USyd DSc UNSW FTSE CPEng CEng PE Dist.MASCE FIStructE FIEAust.

Research Interests: High-strength steel structures, steel-concrete composite structures, steel-timber hybrid structures, concrete structures, arches, geometric non-linearity, pavement thermo-upheaval buckling, railway thermo-lateral buckling, design for deconstructability, low-emissions structural paradigms, forensic engineering.

CARMICHAEL, D G
Professor
BE MEngSc USyd, PhD Cant, CPEng, FIEAust, MASC

Research Interests: Management, systems applications of optimisation, synthesis: Identification & analysis: Contracts & disputes: Project delivery: Construction operations: Project management & management functional areas including risk, economics, finances, people resources & scope: Construction management: Problem solving & decision making.

DACKERMANN, ULRIKE
Lecturer
Dipl.-Ing. Univ., Technical University of Mu-nich (TUM), PhD UTS

Research Interests: Structural Health Monitoring, Non-Destructive Testing, Damage Detection, Structural Dynamics, Artificial Intelligence, Timber Engineering.

DAVIS, STEVEN
Senior lecturer
Chair, Teaching & Learning Committee BE PhD UNSW

Research Interests: Online Assessment, Virtual Reality, Project Scheduling, Safety, Construction Defects and Rework.

DOUGLAS, KURT
Pells Sullivan Meynink Senior Lecturer of Rock Mechanics,
Chair External Relations
BE (Hons1) USyd, PhD UNSW

Research Interests: Lie in the field of rock mechanics and dam engineering. Predicting field properties of rock masses continues to be a major challenge for us to address. My dams research focusses on spillway erosion and backward erosion of dams.

EISENTRAGER, SASCHA
Lecturer
Doctor of Engineering (Computational Mechanics), Otto von Guericke University Magdeburg, Germany

Research Interests: Sascha's research is within the context of structural health monitoring (SHM) applications, particularly with the development of efficient numerical methods for the analysis of wave propagation phenomena in thin-walled structures. Therefore, the propagation of elastic guided waves (Lamb waves, Love waves, Rayleigh waves, etc.) is an important area for his innovative high order finite element and fictitious domain approaches.

FOSTER, STEPHEN
Professor and Acting Dean of UNSW Engineering, BE NSWIT, MEngSc PhD UNSW, MIEAust, FIEAust

Research Interests: Behaviour of structural systems (buildings and bridges) constructed of reinforced and prestressed concrete. I'm particularly interested in bringing new and advanced materials technologies to the engineering of structures. My interests are in the use of high and ultra-high performance concretes, fibre-reinforced concretes and geopolymer concretes and in use of carbon fibre technologies for strengthening and repair of structures and structural systems. I develop physical-mechanical models for use in advanced computational and numerical tools such as FEM and for their use in the study of behaviour of concrete structures that are subjected to extreme events.

GAO, WEI
Professor
BE HDU, ME PhD Xidian, MIIAV, MAAS

Research Interests: Uncertain modelling & uncertain methods: Vehicle-bridge interaction dynamics: Wind and/or seismic induced random vibration: Train-rail-sleeper-foundation-tunnel/bridge system: Stochastic nonlinear system: Vehicle dynamics & vehicle rollover: Structural optimization & control: Smart structures: Stability & reliability analysis.

HAJIMOHAMMADI, AILAR
Senior Lecturer
Ph.D. University of Melbourne

Research Interests: Examines the chemistry of materials to develop innovative construction elements with attractive properties. She is also investigating waste management and resource recovering strategies towards the circular economy in civil and construction projects.

HAMED, EHAB
Associate Professor
BSc MSc PhD Technion

Research Interests: Viscoelastic behaviour of materials and structures, strengthening of structures with FRP composite materials, sandwich panels.

HOLDOM, ROBERT
Senior Lecturer

Research Interests: Construction management.

KASHANI, ALIREZA
Lecturer
BSc, MSc Amirkabir University of Technology, Tehran
PhD University of Melbourne

Research Interests: Lecturer and Churchill Fellow in Sustainable Construction Automation and 3D Printing with extensive experience in research, development, and commercialisation of advanced and sustainable construction materials. Research areas include development of novel high-performance materials and techniques for construction 3D printing, and sustainable construction materials for the 'Circular Economy' including wastes valorisation, low-carbon construction materials and sustainable concrete.

KHALILI, NASSER
Professor and Acting Head of School CVEN
BSc Teh, MSc Birm, PhD UNSW

Research Interests: Mechanics of unsaturated soils: Flow & deformation in double porosity media: Numerical methods applied to geotechnical engineering: Pavement engineering.

KHOSHGHALB, ARMAN
Senior lecturer
BEng, MEng, Sharif University of Technology, Tehran, PhD UNSW

Research Interests: Mechanics of unsaturated soils, coupled analysis of porous media, advanced numerical methods in geomechanics, modelling discontinuities in porous media, large deformation analysis in geomechanics, stabilisation techniques in computational geomechanics, constitutive modelling of geomaterials, dynamic properties of geomaterials.

KIM, TAEHWAN
Lecturer
BSc, MSc KAIST, PhD Purdue USA

Research Interests: Advanced and sustainable infrastructure materials: Thermodynamics in cementitious materials and the modelling of their chemical process: Advanced materials characterization techniques: fundamental understanding of chemo-physical reactions in cementitious materials: Microstructure evolution of cementitious materials: Utilizing natural and waste materials to develop low carbon foot-print materials.

RUSSELL, ADRIAN
Associate Professor
BE, PhD UNSW, PGCert Bristol

Research Interests: Applied unsaturated soil mechanics; Liquefaction of variably saturated soils and tailings; Fundamental modelling of soils linking microstructure to large scale behaviour; Fundamental rock mechanics: Fibre reinforced soils.

MAKKI ALAMDARI, MEHRISADAT
Lecturer
BSc Sharif, MSc Iran University of Science and Technology, Mech Eng
Manitoba, PhD UTS

Research Interests: Structural Health Monitoring, vibration analysis and testing, structural dynamics, inverse dynamic problems, signal processing and data mining. Mehri is on the Executive of the Australian Network of Structural Health Monitoring (ANSHM), and a member of The International Society for Structural Health Monitoring of Intelligent Infra-structure (ISHMII).

SHEN, JOHNSON XUESONG
Senior Lecturer
BEng, MSc Nanjing, PhD Hong Kong Polytechnic University

Research Interests: Digital Twins, Artificial Intelligence, Smart Sensing, Autonomous Systems, Internet of Things, Mixed Reality, and their applications in the construction, operation, and maintenance of civil infrastructure and built environment.

SONG, CHONGMIN
Professor and Director CIES
BE ME Tsinghua, DEng Tokyo

Research Interests: Scaled Boundary Finite-Element Method, Mesh Generation, Dynamic Soil-Structure Interaction, Structural Dynamics & Earthquake Engineering, Fracture Mechanics, Elasto-Plastic-Damage Constitutive Modelling.

VALI POUR GOUDARZI, HAMID REZA
Associate professor
BE, MEngSc, PhD UNSW

Research Interests: Structural mechanics; De-elopment of innovative hybrid steel-timber-concrete structures with emphasis on sustainability and improved structural performance; Behaviour of structures subjected to extreme loads such as earthquake, impact, blast and explosion: Computational mechanics and non-linear finite element modelling of structures: Constitutive modelling of materials.

ZHAO, XIAO LIN (JOSHUA)
Professor and Associate Dean (International), Faculty of Engineering
BE, ME Shanghai Jiao Tong University, PhD and Doctor of Engineering, USyd
MBA (Executive) UNSW/USyd

Research Interests: Current research focuses on hybrid construction utilising seawater, sea sand concrete and fibre reinforced polymers; rehabilitation of aging infrastructure using advanced composite materials; and ultra-high strength steel structures.

EMERITUS PROFESSORS

FELL, ROBIN

TIN LOI, FRANCIS

GILBERT, IAN

VALLIAPPAN, SOMASUNDARAM

CENTRE RESEARCH STAFF

CIES Staff

Chhor, Allen	Senior Research Associate
Chilwesa, Masuzyo	Research Associate
Hassanieh, Amirhossein	Research Associate
Liu, Lei	Postdoctoral Fellow
Masoumi, Saeed	Research Associate
Parvez, Md Ahsan	Postdoctoral Fellow
Saputra, Albert	Postdoctoral Fellow
Shahbodaghkhan, Babak	Senior Research Associate
Vahab, Mohammad	Research Associate
Vo, Thanh Liem	Research Associate
Wu, Di	Research Associate
Xing, Weiwei	Research Associate
Yu, Yuguo	Research Associate
Zhang, Junqi	Research Associate

Visiting/Adjunct Academics

Aldred, James	Adjunct Associate Professor
Eisentrager, Johanna	Visiting Fellow
He, Yiqian	Visiting Fellow
Wei, Minghai	Visiting Fellowr
Zhang, Zihua	Visiting Fellow

PROFESSIONAL AND TECHNICAL STAFF

Technical Services - Kensington

PAUL GWYNNE
Lab Manager

ANTHONY MACKEN
Senior Technical Officer

WILLIAM TERRY
Senior Technical Officerr

LUIZ PETTERSEN
Technical Officer

RUDINO SALLEH
Technical Officer

TIMOTHY WESTON
Technical Officer

Technical and Professional - Heavy Structure Laboratory Randwick

ZHEN-TIAN CHANG
Laboratory Manager

SANJEEWA HERATH
Senior Technical Officer

TUAN LE
Postdoctral Technical Assistant

RONALD MONCAY
Senior Technical Officer

GREG WORTHING
Technical Officer

Research Centre Management

THERESA WISNIEWSKI
CIES Manager

FAREWELLS IN 2020

Farewell and thank you to Mario Attard

At the end of 2020 the School sadly farewelled CIES academic Associate Professor Mario Attard, our Associate Head – Academic - responsible for many years in overseeing the vast teaching and learning enterprise of the School.

It was a very appropriate leadership position, as Mario Attard has long been an advocate for teaching excellence and innovation. The influence of a great teacher can last a lifetime, and students never forget those who inspire, challenge, clearly explain complex material, and are eager to assist student learning. All of these attributes were Mario's.

In 2008 he was the recipient of the Vice-Chancellor's Award for Teaching Excellence. The Awards measured students' learning experience and outcomes, as well as the staff member's scholarly approach to develop their teaching. CVEN student teaching awards and alumni memories always placed Mario Attard in the best teacher ranks.

TEACHING INNOVATION. CIVIL WITH ARCHITECTURE!

Creativity is not always a word associated with engineers or engineering. Yet as Mario and his colleague Dr Zora Vrcelj pointed out, 'creativity is essential in all branches of engineering and is of paramount concern in engineering design'.[1] Gifted with their own determined creativity – the two structural engineering colleagues designed the innovative multi-disciplinary single degree, the first in Australia - a BE Civil with Architecture degree.

As a member of the School's (Centre's) structural engineering group, Mario has been part of a long history of successful research into concrete and composite structures

Working with UNSW colleagues from the Faculty of the Built Environment and with the support of Head of School, Nick Ashbolt, the new degree was launched in 2007, and was an immediate success. It combines civil engineering courses with almost a full year of architecture courses. Its aim is to provide an appreciation of architectural principles, an understanding of both architectural design and better interaction between architects and engineers.

Mario himself was a proud alumnus of the School, graduating with a BE Hons in civil engineering in 1977, and awarded his PhD in 1985. His structural engineering thesis topic, supervised by Prof Al Kabaila, was on the topic of "The elastic flexural-torsional response to thin-walled open beams." He was appointed as Senior Lecturer in 1992, and was promoted to Associate Professor in 2001.

IMPACT OF RESEARCH ON AUSTRALIAN STANDARDS

As a member of the School's (Centre's) structural engineering group, Mario has been part of a long history of successful research into concrete and composite structures, as well as concrete technology and structural mechanics.

Mario was particularly involved in analysis of buckling – based on hyperelastic constitutive modelling of materials – and developing improved models that would provide a much better measure of the extent of deformation for an applied shear stress. He supervised many PhD students in these areas, and has authored or co-authored over one hundred research papers.

Stephen Foster and Mario Attard's work on confinement of the compressive core in high strength concrete columns and in modelling the compressive zone in high strength concrete has been incorporated into the Australian Standard for Concrete Structures, AS3600. Their work facilitated an expansion of the scope of the Standard to cover design usage of high strength concrete – a change that was long requested by the profession.

"Mario always worked for the benefit of students and spoke up when he felt proposed policy changes would have an adverse effect on the student experience."

SCHOOL STALWART

Above all Mario was an indefatigable worker for the CVEN cause –a trusted and utterly reliable colleague, responsive to students and professional staff, managing the endless changes in the curriculum, student services, staffing resources and university timetabling.

Mario was always aware of student needs. "Some students were very vulnerable, and it was up to us to find solutions to make their circumstances better." he said. "Each day if I made life better for one student, I was happy."

School Business Manager Anthony Dever summed it up when he said, "Mario had a real love for the School of Civil and Environmental Engineering. He was a passionate teacher and wanted all students to succeed and work to the best of their abilities. He always worked for the benefit of students and spoke up when he felt proposed policy changes would have an adverse effect on the student experience. Mario was fair and honest in his dealings with students and they found him very approachable. Mario was highly regarded in the School and across Faculty and will be extremely missed."

We will certainly miss him, and we wish him the very best in his new world.

[1]Vrcelj Z, Attard M, Margalit H and Plume J, 'New Civil Engineering with Architecture Program @ UNSW' Conference Proceedings of Connected2007 International Conference on Design Education, UNSW Sydney, Australia, July 9-12 2007.

Farewell and thank you David Carmichael

It is hard to believe but at the end of 2020 our systems and construction management guru Professor David Gordon Carmichael became an Emeritus Professor, retiring after thirty-three years of research and teaching excellence at UNSW.

David obtained his BE (Hons) and MEngSc at the University of Sydney, and his PhD from the University of Canterbury. He became a Fellow of the Royal Society of New South Wales, Fellow of the Institution of Engineers Australia, Life Member of the American Society of Civil Engineers and a graded arbitrator and mediator. He joined UNSW academic staff as Professor in 1987, taking on the leadership of the Engineering Construction and Management Department, and became one of UNSW's longest serving Professors and contributors to UNSW's development. He coordinated departmental activities, teaching, research and industry liaison until departments were disestablished in a university restructure in 1998, and beyond that was involved in extensive UNSW administration.

His breadth of technical knowledge is matched by few people. In teaching, he developed fourteen different postgraduate courses including comprehensive study guides, and in one year delivered all fourteen courses together with projects - enough for two full masters coursework degrees.

David Carmichael was Foundation Director of the Master of Business Technology (MBT) program, introduced to give management skills to engineers. In the early 1990s he embarked on offering distance learning within the Faculty's postgraduate coursework MEngSc and MBT programs, keeping the content relevant and topical to address industry demand. The program was also taken offshore to Singapore, where the programs further thrived.

David has been described as a polymath. He has shunned the narrow focus adopted by many academics, and has published in journals and books covering multiple disciplines ...

With risk management and problem solving among his expertise, it should come as no surprise that in the classroom Professor Carmichael was constantly challenging his students to apply their learning, weigh up their options, test their limits and when necessary shift the goal posts, in his efforts to create industry leaders who are innovative thinkers. Students, in the main, appreciated his efforts.

David was awarded the Vice Chancellor's Award for Teaching Excellence, UNSW Australia, 2014, and Engineers Australia Engineering Excellence Award – for his work and leadership of the Leighton Masters program. The excellence of the distance MEngSc program had attracted the then largest construction company in Australia, to work with David to design and implement a bespoke MEngSc program in project management specifically designed for Leighton staff in Australia and overseas.

Moving into the challenges of the twenty-first century, David was team leader of the Construction Innovation and Research Initiative (CIRI) within the School. He was interested in sustainability practices within the construction industry and conducting research into carbon trading; operations and carbon emissions; incorporating carbon emissions and carbon credits into feasibility studies, aka 'carbon finance'; and CDMs (Clean Development Mechanisms) for developing countries.

David has been described as a polymath. He has shunned the narrow focus adopted by many academics, and has published in journals and books covering multiple disciplines including structural engineering, construction, management, finance, economics, sustainability, project management, construction management, property, control systems, systems engineering, and problem solving. With his extensive industry involvement, he is unique in being able to seamlessly transition between practice, teaching and research.

Within the fields of systems, construction and projects, Professor Carmichael is regarded as one of the most knowledgeable people in Australia and abroad – both in breadth and depth.

Within the fields of systems, construction and projects, Professor Carmichael is regarded as one of the most knowledgeable people in Australia and abroad – both in breadth and depth. He has held appointments at The University of Western Australia, The University of California (Berkeley), The University of Waterloo, Ontario, The Asian Institute of Technology, The University of Canterbury, The University of Auckland, Griffith University, The University of Technology, Mara, Hong Kong Polytechnic University, The University of British Columbia, and Chulalongkorn University.

Much of what Professor Carmichael writes is considered to be left-field, and some might be considered controversial, maverick and uncompromising. Commonly, in an attempt to promote healthy discussion for the advancement of the state-of-the-art of the professions, he shows that the status quo is flawed. The challenge for Professor Carmichael has always been to get people to acknowledge that the state-of-the-art needs improving and not dogmatically defend current situations.

David is the author and editor of twenty-five books and over two hundred papers in structural and construction engineering and construction and project management, winning Best Paper Awards from the journals involved for work of long-lasting value. He has seven sole-authored research monographs and has made numerous seminal contributions to knowledge over multiple disciplines.

He holds engineering practice credentials: CPEng NER, Registered Professional Engineer (NER - National Engineering Register), Engineers Australia; Chartered Professional Engineer, Engineers Australia; APEC Registered Engineer (Asia Pacific Economic Cooperation); and IntPE(Aus), International Engineering Association (IEA) Registered Engineer.

Not one to slow up, David served on UNSW Council from 2018 -2020 as one of two academic representatives voted in by academic staff, while continuing during this period to teach, and publish more than twenty articles in international peer-reviewed journals.

"If I had any influence over what a civil engineering curriculum should look like, I would recommend heavy doses of problem solving, modelling and decision making, which generic skills will stay constant over time."

David defined himself as first and foremost a systems person. This necessarily entails, in all endeavours, amongst other things, looking at the bigger picture first before looking at the detail. Systems thinking strips everything to its core features unencumbered by jargon and detail, and it provides a systematic structure for viewing the world and problem solving.

"If I had any influence over what a civil engineering curriculum should look like, I would recommend heavy doses of problem solving, modelling and decision making, as these generic skills will stay constant over time. A personal regret is that civil engineering programs, at both UNSW and elsewhere, have discarded systems studies in favour of short-term area-specific detail, such that graduates often fail to see the bigger picture and the component interrelationships until many years into their post-university working life." (CVEN history p. 249)

We thank David for all his amazing work for the School and the engineering profession, and wish him all the very best in his continued research and ongoing projects.

"Tony always paid great attention to detail and you could guarantee that any test results he produced would be accurate."

Above: Quieter days in the School labs. Angie Spano, Tony Macken and Trinh Cao with testing equipment. Circa 1980s

Thank you Tony Macken!

In 2020 we farewelled Senior Technical Officer and major School stalwart Tony Macken. Tony had worked quietly and assiduously for the School for 42 years.

The School's infrastructure laboratories, where Tony worked, provide essential support to the teaching and research of the geotechnical, heavy structures, materials, transport and construction management disciplines within the School.

The School believes that it is essential that our students leave this university with practical 'hands-on' experience to complement their academic achievements. Amongst their many research support duties, Technical Officers service undergraduate classes using the laboratories, as well as assisting postgraduate and honours students with thesis experiments.

Since joining the school in 1978, Tony has served under eleven Heads of School, eight Deans of Engineering, and seven Vice-Chancellors. More importantly, Tony has assisted dozens of School academics and possibly thousands of students in their laboratory activities. Over the course of his working life, he witnessed the quadrupling of student numbers in the School, and the reduction of technical staff – sometimes it wasn't just the concrete being stressed.

Infrastructure Lab Manager Paul Gwynne noted that "Tony always paid great attention to detail and you could guarantee that any test results he produced would be accurate." It's only been a few months but, he says, "Tony's colleagues are already missing his wonderful dry sense of humour and sharp wit."

A man of few words, usually standing at the back of staff groups in photos, but forced to take front place at his own farewell (see pic) Tony's message to us all was classically short and very sweet. "My retirement date has arrived. I would like to thank you all for being part of my life over the past 42 years. You have been more than just work colleagues, but good friends. I wish you and your families all the best for the future. Best wishes, Tony"

Our best wishes to you Tony. We hope you enjoy your so well-earned retirement after all your dedication and hard work for the School!

PHD GRADUATES 2020

AL-DAMAD, IMAN MUNADHIL ABBAS
Fatigue Behaviour of Steel Fibre Reinforced Concrete Pavements
Supervisor: S J Foster

LE, TUAN
Buckling of high-strength steel beams
Supervisor: M A Bradford & H Valipour

LI, SHIJIN
The mechanical consequences of internal erosion on gap-graded soil
Supervisor: A R Russell

MAC, THI NGOC
A Bounding Surface Viscoplasticity Model for Time dependent Behaviour of Saturated and Unsaturated Soils including Tertiary Creep
Supervisor: N Khalilli

MAHMOOD, AZIZ HASAN
Development of a high-density geopolymer concrete for coastal protection applications
Supervisor: S J Foster & A Castel

MAHMOOD, S M FAISAL
Moment redistribution and post-peak behaviour of steel fibre reinforced concrete flexural members
Supervisor: S J Foster

NGUYEN, TUAN ANH
Options and flexibility in PPP toll road projects
Supervisor: D C Carmichael

NGUYEN, QUANG DIEU
Durability properties of low-carbon concrete incorporating alternative supplementary cementitious materials and manufactured aggregate
Supervisor: A Castel & T W Kim

SHAHBAZI, BABAK
A Mathematical Optimization Approach to account for Career Development, Job Security, and Job Satisfaction in Human Resource Planning in Construction Organizations
Supervisor: D Rey & A Akbarnezhad

SUN, YUTING
A second order moment approach for addressing the uncertainty around financial variables in life cycle costing (LCC) analysis
Supervisor: D C Carmichael

WANG, YIXIN
Buckling of high-strength steel members
Supervisor: H Valipour & M Bradford

SECTION 3

OUR RESEARCH

CIES MAJOR RESEARCH GRANTS AND AWARDS IN 2020

In 2020 CIES researchers won over $6M in government and industry research grants, awards and fellowships, including $2.6M in the highly competitive Australian Research Council (ARC) awards.

Heartiest congratulations to CIES academics Professor Mark Bradford, Professor Stephen Foster; Professor Wei Gao, Dr Souradeep Gupta, Dr Ailar Hajimohammadi, Professor Nasser Khalili, Dr Taehwan Kim, Dr Mehri Makki Alamdari, Professor Adrian Russell, Dr Babak Shahbodagh Khan, and, in collaboration with rCITI, Dr David Rey.

Australian Federal Government Cooperative Research Centre Project (CRC-P) Grant 2020

Professor Nasser Khalili, Dr Ailar Hajimohammadi and Dr Babak Shahbodagh Khan

A joint CIES/industry project will receive $3m to convert paper and plastic landfill waste into construction materials.

A COLLABORATIVE PROJECT involving UNSW CIES researchers will develop technology to divert up to 10,000 tonnes of paper and plastic waste in Australia into construction materials used to build roads.

CIES researchers, in partnership with State Asphalts, Closed Loop, Primaplas and Asphaltech, will work to convert mixed plastic and paper waste into value-added additives for use in asphalt. The project will aim to recover 3000 tonnes of material per year which would otherwise be exported as waste or landfilled.

The partnership received $2.98 million in federal funding through a Cooperative Research Centre Project (CRC-P) grant to develop the technology which will help transform the recycling sector in Australia.

"Australia disposes more than 4 million tonnes of plastic and paper waste each year at a cost of $600 million."

CIES Professor Nasser Khalili said UNSW will conduct important research to address the lack of commercial technologies available to recycle paper and plastic.

"Australia disposes more than 4 million tonnes of plastic and paper waste each year at a cost of $600 million. Our current recycling infrastructure lacks capability and capacity, and instead relies on landfill and exporting waste," he said.

"This project directly addresses the gap by developing technology to recycle these materials into materials which also have tremendous potential for commercialisation and international exportation."

State Asphalts and Asphaltech will use the products for construction projects, while distribution partners Closed Loop and Primaplas will source waste materials and distribute recycled products.

Professor Khalili will lead the UNSW research on the project along with Dr Ailar Hajimohammadi and Dr Babak Shahbodagh. He said the work will create technical leadership in the recycling sector, improve competitiveness through reduced infrastructure costs and create environmental benefits.

"The project will advance new pathways to addressing Australia's recycling capability and capacity through developing value-added products to the competitive advantage of Australian road construction industry. The solutions developed will accelerate the transformation of plastic and polymer-coated paper waste to high-end, safe and marketable products with enhanced engineering properties," he said.

The CRC-P program is an Australian federal government initiative to support collaborations between industry, researchers and the community. It is a proven model for linking researchers with industry to focus on research and development for practical use and commercialisation.

Original newstory from https://newsroom.unsw.edu.au/news/science-tech/unsw-joins-industry-devel... by Stefanie Menezes

CIES ARC Discovery and Linkage Project grants awarded in 2020.

Congratulations to Scientia Professor Mark Bradford, Professor Stephen Foster, Professor Wei Gao, Dr Ailar Hajimohammadi and Dr David Rey.

The ARC's Discovery Scheme aims to expand the knowledge base and research capacity in Australia and support research that will provide economic, commercial, environmental, social and/or cultural benefits for the nation.

The ARC encourages the transfer of skills, knowledge and ideas as a basis for securing commercial and other benefits of research.

THE ARC LINKAGE PROGRAM promotes national and international research partnerships between researchers and business, industry, community organisations and other publicly funded research agencies. The ARC encourages the transfer of skills, knowledge and ideas as a basis for securing commercial and other benefits of research.

Details of CIES researchers ARC DP& LP grants as follows:

Discovery Project DP210102833

VULNERABILITY OF STEEL LATTICE TOWERS TO FIRE.

Scientia Professor Mark Bradford

PROJECT SUMMARY
Steel lattice towers find widespread use as structural components in electricity transmission systems and as base towers in UHF and microwave communications networks. They tend to be protected from bushfire damage by active backburning or clearing through their easement or right of way, because the response of towers to bushfires is surprisingly unknown, and it is not known if they can provide passive protection without clearing/backburning. A world first, this project aims to use advanced numerical techniques to assess the fragility and resilience of lattice towers in fire using a systems approach based on fire load data available with a further goal to explore potential pragmatic strengthening strategies if necessary and feasible.

Award: $324,603

Linkage Project LP200100531

CONCRETE MIXES FOR DURABILITY: A HYBRID MATHEMATICAL OPTIMISATION APPROACH.

Professor Stephen Foster, Dr Ali Nezhad, Dr David Rey, Mr David Hocking, Dr Ailar Hajimohammadi, and Dr Farzad Moghaddam.

Industry Partner: Boral

Professor Stephen Foster

PROJECT SUMMARY
This project will lead a paradigm shift in concrete mix design methodology, which is currently focused on meeting the mechanical performance objectives of concrete, to a holistic approach that maximises durability of concrete alongside its mechanical performance.

The approach is based on a hybrid methodology involving mathematical optimisation of concrete mix based on empirically formulated objective functions for durability properties and mechanical properties.

"These projects will lead to a paradigm shift in concrete design methodology..."

The multi-objective nature of proposed optimisation model will allow simultaneous consideration of several design objectives including minimising the overall risk of cracking, minimising the permeability and maximising the rate of strength development.

Award: $534,117 ($384,117 ARC + $150,000 industry).

Boral General Manager – Innovation Development Louise Keyte said the ARC grant was a great result for the working team and recognises the value of its collaboration with UNSW.

"These projects will lead to a paradigm shift in concrete design methodology – which has traditionally focused on meeting mechanical performance objectives – to a more holistic approach that maximises durability and longevity of concrete as well as mechanical performance and reduces environmental impacts," Keyte said.

Discovery Project DP210101353

TOPOLOGICAL DESIGN OF MECHANICAL META-STRUCTURES

CIES researcher Professor Wei Gao is involved in an ARC Discovery Project administered by UTS. Professor Gao is the second Chief Investigator (CI).

Associate Professor Zhen Luo; **Professor Wei Gao,** Dr Paul Walker, Professor Michael Wang.

PROJECT SUMMARY

This project aims to establish a new computational design methodology to address current challenges facing creation of ultralight structures with ultra-high-performance characteristics.

The latest technologies in structural topology optimization and its correlated numerical simulation and structural analysis methods will be unified towards an integrated design framework.

Expected outcomes include an advanced generative design platform for discovering novel geometries to underpin new meta-structure architectures, validated by appropriate fabrication techniques considering their geometric complexity.

ARC Future Fellowship: Adrian Russell

In 2020 CIES Professor Adrian Russell was awarded an ARC Future Fellowship to the value of $1,040,000 for his crucial research on preventing mining disasters by improving the safety of tailings storage facilities (TSFs).

PROFESSOR RUSSELL is an expert in unsaturated soil mechanics and a world leader in the use of in-situ tests to characterise the properties of unsaturated geomaterials. He has worked on the issue of tailings liquefication for some time, most recently on an ARC Linkage project involving several universities and mining companies.

Tailings are the waste products of mining, a mixture of water and soil-sized particles. They are often stored on mining sites and contained by embankment perimeter walls. These tailings dams can be four kilometres in diameter, or several hundred metres high. In fact, the biggest tailings dams are the largest humanmade structures on the planet.

But these dams carry a high risk due to the notorious potential of tailings to liquefy, when they suddenly transform from a solid to a fluid-like material, sometimes involving failure of the embankment walls enabling the tailings to be released and flow.

In 2019 the Brumadinho tailings dam, at an iron ore mine in Brazil, suffered a catastrophic failure, releasing 12 million cubic metres of toxic tailings. The mudflow obliterated the mine's offices and cafeteria and all the farms and houses in its path. It killed over 250 people and, according to Brazil's National Water Agency, could end up polluting over 300 kilometres of river.

ABOVE: Brumadinho tailings dam mudslide Brazil 2019

"On average" says Professor Russell, "there are two large failures a year around the world, many of which kill dozens of people and severely damage the environment by covering wide areas in tailings which are sometimes toxic."

"Despite fairly advanced knowledge of soil mechanics and advanced engineering techniques being applied to their design and construction, no one fully understands tailings properties and their potential to liquefy."

"My Future Fellowship will address how tailings dams liquefy, focussing mostly on liquefaction due to earthquake loading. It applies to tailings dams that are still being filled and enlarged to accommodate more and more tailings, plus how they are likely to perform over the next 10,000 years as they lie in situ once the mine has closed.

"Despite fairly advanced knowledge of soil mechanics...no one fully understands tailings properties and their potential to liquefy."

I will consider the extreme earthquakes they are likely to experience, the extreme wetting and drying events they are likely to experience, as well as how their properties will change with age, and how engineers can use existing tools like the cone penetration test to determine their susceptibility to liquefaction.

The anticipated outcomes from Russell's work will be updated industry guidelines for improved design and management of TSFs, thus reducing environmental disasters and saving lives.

As 2020 Acting Head of School Nasser Khalili noted, "The Future fellowship is an outstanding achievement, and testament to Adrian's relentless pursuit of excellence, commitment to quality, and his national and international standing as a leader in the field."

ARC Discovery Early Career Research Awards (DECRA): Dr Mehri Makki Alamdari and Dr Souradeep Gupta

In 2020 CIES academics Dr Mehri Makki Alamdari and Dr Souradeep Gupta received ARC Discovery Early Career Research Awards (DECRA). Australian Research Council's DECRA grants support Australia's next generation of researchers working in key priority areas to grow our research and innovation capacity.

72% of bridges in Australia were constructed before 1976

MEHRI'S PROJECT aims to develop a low-cost and robust bridge monitoring framework by advanced data analytics, while Souradeep's research project is to develop durable biochar-foam concrete technology that enhances uptake of carbon dioxide and sulphur oxide.

DR MEHRISADAT MAKKI ALAMDARI

PROJECT SUMMARY

72% of bridges in Australia were constructed before 1976. Currently bridges are inspected by biennial visual inspection, which is expensive, time consuming and subjective. Considering the large number of defective bridges in Australia and around the world and the limited budget of road authorities, this project aims to develop a low-cost and robust bridge monitoring framework by advanced data analytics, solely based on the response of a moving vehicle passing over the bridge, with no equipment to be installed on the bridge.

The project is significant because it opens a new direction for sustainable monitoring of such ageing infrastructure, consequently resulting in the lower costs of maintenance, enhanced safety and extended asset life.

Funding Total $430,075 2021-2023

About Mehri: Dr Makki Alamdari is an expert in structural health monitoring, vibration analysis and testing, inverse dynamic problems, and signal processing. She is the winner of the prestigious JSPS Award (Japan Society for Promotion of Science), is on the Executive of the Australian Network of Structural Health Monitoring (ANSHM), and a member of The International Society for Structural Health Monitoring of Intelligent Infrastructure (ISHMII). Prior to joining UNSW, she was a research fellow in Data61|CSIRO working on structural health monitoring of the iconic Sydney Harbour Bridge.

DR SOURADEEP GUPTA

PROJECT SUMMARY

This project aims to address the pressing need to curb carbon dioxide and sulphur oxide levels in the air through direct air capture technology using foamed concrete with engineered biochar, prepared by pyrolysis of food waste.

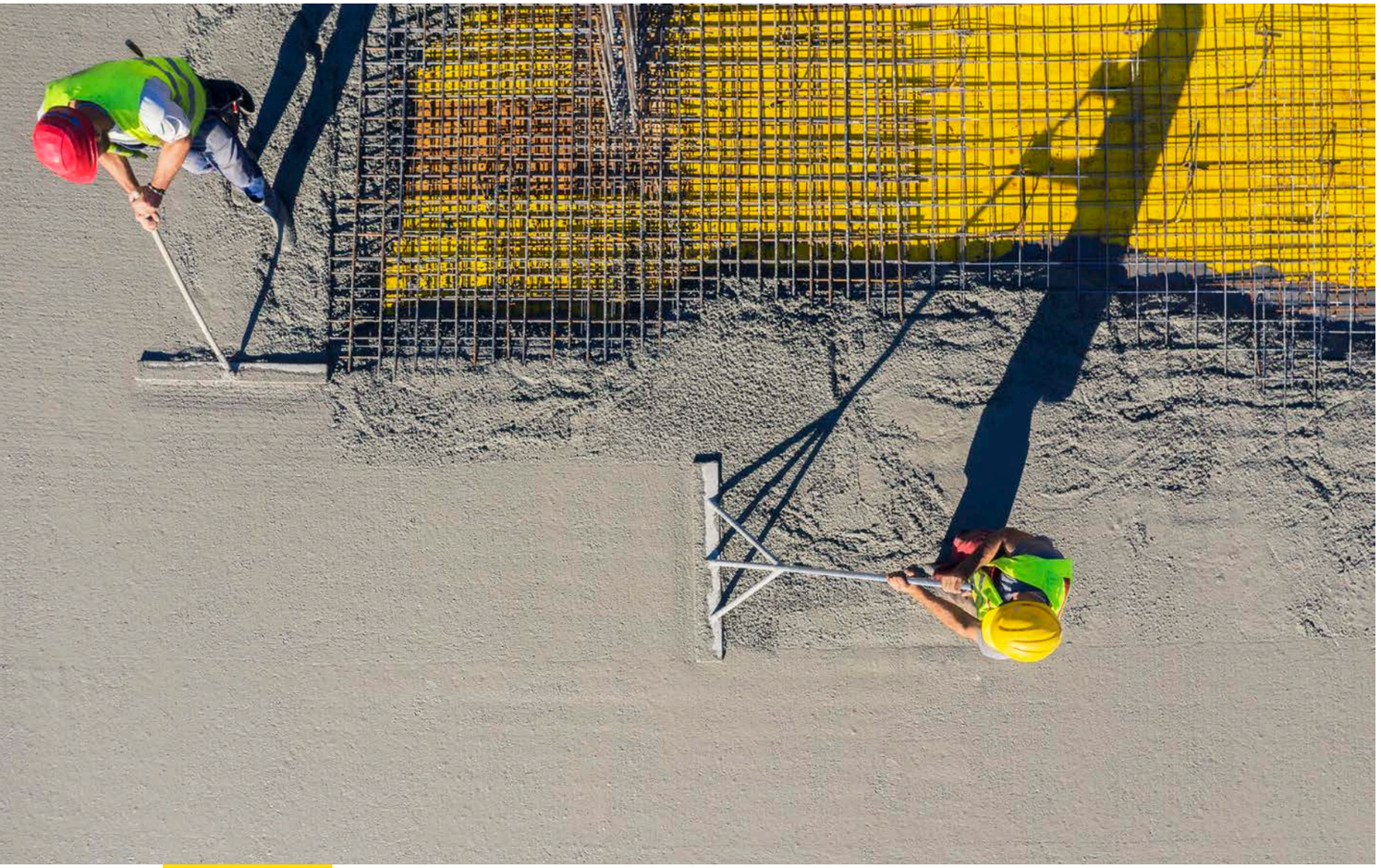
The expected outcome of the project will be a durable biochar-foam concrete technology that enhances uptake of the mentioned pollutants, thus reducing their concentration in the ambient environment. It links to the Australian Government's Science and Research priority areas of Resources and Environmental Change through utilization of waste-stream and offering an adaptive measure to impacts of climate change.

Deploying this technology will offer durable lightweight construction and healthier environments for urban residents.

Deploying this technology will offer durable lightweight construction and healthier environments for urban residents.

Funding Total $450,000, 2021-2023

About Souradeep: Dr Souradeep Gupta is a CIES post-doctoral Fellow and Research Fellow at National University of Singapore (NUS). Dr Gupta holds a Bachelor of Technology (B.Tech) with Honours in civil engineering from National Institute of Technology, India, and Master of Science in Civil and Environmental Engineering from NUS. In 2019, he earned his doctorate degree from NUS for his research on biochar enhanced high performance concrete and self-healing materials.
Dr Gupta has extensive experience in bio-based materials, lightweight concrete, and self-healing cementitious composites. His paper titled "Application of biochar as carbon sequestering additive in cement mortar" has been the 'Most cited' of the papers in Journal of Cement and Concrete Composites (IF = 5.17) since 2017.



NSW Environment Protection Authority (EPA)'s Civil Construction Market Program 2020 grant:

Dr Ailar Hajimohammadi, Prof Stephen Foster and Dr Taehwan Kim

The project aims to unlock new markets from recycled glass in non-structural concrete in civil construction projects in NSW.

Congratulations to CIES academics Dr Ailar Hajimohammadi, Prof Stephen Foster and Dr Taehwan Kim on the NSW EPA grant awarded for their geopolymer project with construction company John Holland.

Funding of $249,987 has been awarded from the EPA's Civil Construction Market Program to help develop and trial a low carbon Geopolymer Concrete (GPC) containing recycled crushed glass as a replacement for virgin sand. The project aims to unlock new markets from recycled glass in non-structural concrete in civil construction projects in NSW.

Dr Ailar Hajimohammadi

Professor Stephen Foster

Dr Taehwan Kim

DR HAJIMOHAMMADI has long been an advocate for sustainable construction materials. Her work investigates potentials for waste minimization and resource recovery, as well as smart design of construction materials and technologies to reduce negative environmental impacts.

One of Dr Hajimohammadi's most recent research publications reveals the benefits of utilizing glass waste in geopolymer concretes as a replacement for natural river sand, and it is this innovative research which forms the basis for the partnership with John Holland.

As she notes, "there is a shortage of natural sand in many countries, and the extraction of sand from rivers damages riverbanks and negatively impacts the coastal ecosystem."

Sand mining causes instability problems to riverbanks, while the biodiversity of aquatic fauna and flora could drastically change as a result. Moreover, water quality may be negatively affected in the long run.

Yet due to increasing road and building construction projects, the demand for sand mining continues to grow. This demand cannot be sustainably met by natural river sand, and there is an urgent need for a suitable replacement, such as glass waste. Glass is rich in amorphous silica and can make a stronger geopolymer matrix compared to that of sand aggregates.

Working with a major infrastructure construction and engineering company means that Dr Hajimohammadi and the team have a wonderful opportunity to really test and prove the performance of the recycled glass-based GPCs. This in turn could lead to the development of industry specifications and standards to facilitate industry uptake of more environmentally friendly, lower carbon construction materials.

NSW Environment Minister Matt Kean said the EPA funding will encourage the reuse of construction and demolition waste and encourage the use of recyclable materials such as glass and plastics in civil construction projects.

"Through this grant program, the NSW Government is boosting the future of recycling services in NSW, and helping industry prepare for the ban on the export of waste glass from Australia, coming into effect January next year" said the Minister.[2]

Dr Hajimohammadi and the team will begin this research project with John Holland in December this year. All enquiries to ailar.hm@unsw.edu.au.

[2] https://www.epa.nsw.gov.au/news/media-releases/2020/epamedia200908-paving-the-way-for-recycled-glass [accessed 07/04/21]

CIES RESEARCH GRANT INCOME 2020

UNSW INVESTIGATORS	PROJECT TITLE	SPONSOR NAME	2020 AMOUNT
Chang, Z	Investigation of Gripping Efficiency of a Pre-Stress System	STS Systems | Contract Research	9,290.00
Foster, SJ Chang, Z	Investigation of steel fibre reinforced shotcrete (SFRS) tensile stress-strain behaviour	McMillen Jacobs Ltd | Contract Research	6,150.00
Gao, W Li, G Zhang, Y	ARC Research Hub for nanoscience based construction material manufacturing (Project 1)	Monash University | ARC Industrial Transformation Research Hubs - Shared Grant and Industry Partner Contributions	30,000.00
Ge, L	Joint Development of Smart Spatial Technologies	Huitian Jiuzhou Technologies Co Ltd | International Contract	100,000.00
Ge, L | Du, Z	Integrated Optical and SAR Satellite Remote Sensing (iOS -Sat)	Beijing Piesat Information Technology Co Ltd | International Contract	150,000.00
Gilbert, RI	Time Dependent Behaviour of Fibre Reinforced Concrete Structures.	Australian Research Council | Discovery Project	165,000.00
Gilbert, RI	Shrinkage, cracking, self-healing and corrosion in blended cement concrete	ARC Linkage Project, shared grant with UTS | Industry Partner- Cement Concrete & Aggregates Australia	284,156.00
Hajimohammadi, A Kim, T Foster, SJ	Next generation sustainable concrete: trialling recycled glass in geopolymer concretes	John Holland Pty Ltd | NSW EPA Civil Construction Market Program Shared Grant	60,497.00
Kashani, A Kim, T Foster, SJ	Development of Sustainable Concrete with Glass Waste Mixes	Department of Industry Science, Energy and Resources | Innovation Connections Contract | Industry Partner XL Precast Pty Ltd	99,969.00
Khalili-Naghadeh, N	Land Subsidence - Vicinity of Armoury Road, Llandilo (St Marys Central Precinct Release Area / Jordan Springs East)	NSW Public Works Advisory | State Government Contract	14,044.00
Khalili-Naghadeh, N Khoshghalb, A	Non-isothermal dynamic strain localisation in unsaturated porous media	Australian Research Council | Discovery Project	100,000.00
Khalili-Naghadeh, N Russell, A	Modelling creep and time-dependency in unsaturated soils	Australian Research Council | Discovery Project	110,000.00
Khalili-Naghadeh, N Russell, A	Experimental investigation and constitutive modelling of reactive soils	ARC Linkage Project: Industry Partners - Department of Planning, Transport and Infrastructure (SA) & PSM Consult Pty Ltd	163,612.00
Khoshghalb, A	Experimental investigation on expansive soil-pile contact behaviour	EIC Activities Pty Ltd | Contract Research	3,646.00
Kim, T Chang, Z	Proposal to the flexural behaviour of the sprayed concrete (shotcrete) with steel fibre for RIX Group	RIX Group | Contract Research	2,845.00
Makki Alamdari, M	Structural Health Monitoring of Bridges	CSIRO - Commonwealth Scientific and Industrial Research Organisation | Data61 - Collaborative Research Project	24,000.00
Russell, A	Geotechnical testing of a soil with Helixbase added to improve properties	Helixbase Pty Ltd | Contract Research	53,600.00
Song, C	Seismic analysis of cracking and deformations in concrete gravity dams	ARC Linkage Project: Industry Partners - Goulburn-Murray Water | Melbourne Water Corporation | Murray-Darling Basin Authority | Sunwater Limited	115,636.00
Song, C	Computational fracture analysis of structures and materials	Australian Research Council | Discovery Project	150,000.00
Song, C	Ship response under corrosion, fatigue and complex sea-state environments	University of Newcastle | ARC Linkage Project Shared Grant	61,566.00
Song, C Tin Loi, FS	3D contact and fracture analysis for safety assessment of structures	Australian Research Council | Discovery Project	136,593.00
Vali Pour Goudarzi, HR	Method maturity test on UHPFRC/UHPC	Sydney Trains | State Government Contract	68,401.00
TOTAL			**1,919,005.00**

CIES LABORATORIES EQUIPMENT AND CAPABILITIES

Our laboratories

CIES research and commercial activities are conducted within extensive physical laboratory resources, with a wide variety of equipment. These state-of-the-art facilities enable us to undertake our cutting-edge research, and thorough and timely industry investigations.

Our Cementitious Materials Laboratory is equipped with cutting-edge facilities for measuring cement and concrete materials characterisation and for durability testing. This includes: Thermogravimetric Analysis (TGA); isothermal calorimeter; laser Flash analyser; Plasma CVD equipment; eleven channels potentiostat for standard steel reinforcement corrosion testing; accelerated carbonation chamber; sorption-desorption testing apparatus and more.

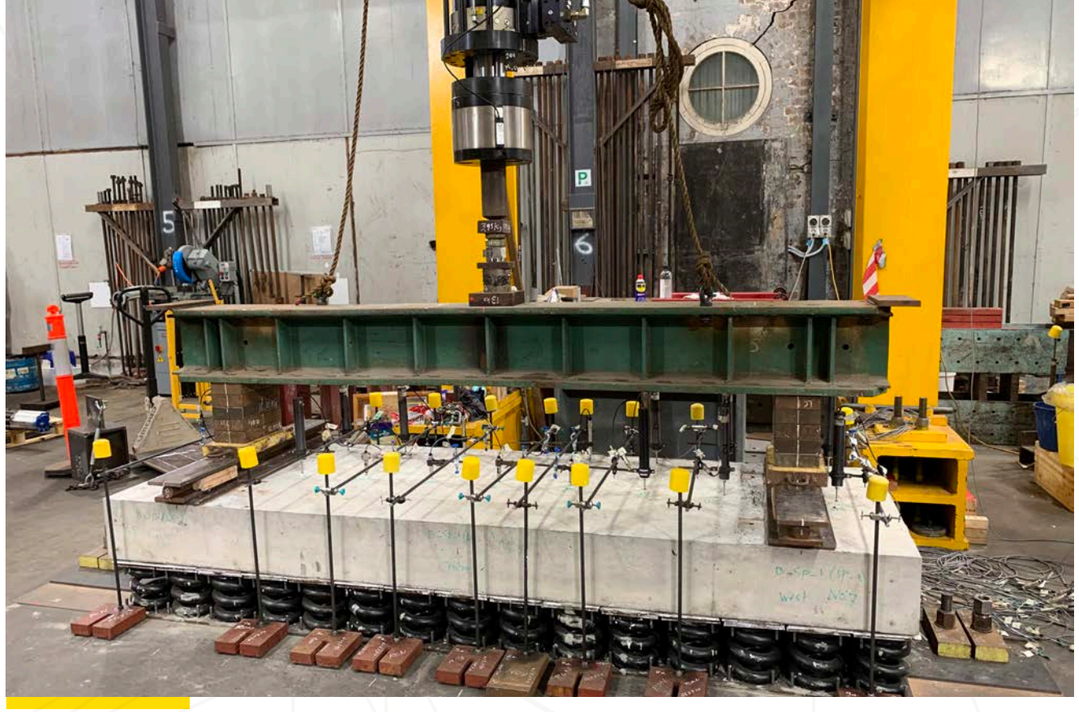
Our Construction Automation Laboratory: This new research facility will be used to fundamentally research, develop, refine, and systematically evaluate automated construction techniques for increased collaboration with industry, leading to rapid technology transfer. The state-of-the-art research facility will enable new methods of digital 3D printing by addressing the reinforcement issue and other main challenges of construction 3D printing.

It can also be used for cross-disciplinary projects by UNSW researchers, the construction industry and other researchers around the world.

CIES can play an important role in construction automation not only in Australia but also internationally by fulfilling the need for a research facility to implement collaborative robots for construction activities. This research facility will be used for other construction automation processes including modular construction and structural assembly, shotcreting, BIM integration, automated demolition, and automated bricklaying. It can also be used for cross-disciplinary projects by UNSW researchers, the construction industry and other researchers around the world.

Our Geotechnical Engineering Laboratories: The scale of capability for geotechnical engineering research and testing is not available in any other university in Australia. Importantly, triplicates (or more) of the most highly used equipment (triaxials and oedometer/CRS frames) are available enabling an ambitious program of experiments to be completed in a timely manner.

Our Heavy Structures Laboratories are equipped with state-of-the-art servo-controlled hydraulic actuators and universal testing machines to maintain a capacity for high load testing, ranging from 10 kN to 5000 kN. We combine strength testing with X-Ray measuring of laboratory specimens under load. This improves understanding at the materials level for the development of refined, mechanically based, structural models.



CIES Testing Capability for Construction Materials

CIES laboratories are well equipped to conduct any type of experiment related to construction materials.

1. MATERIALS

- Concrete (from conventional Portland cement-based concrete to alternative concrete, including 3D printable concrete)
- Asphalt
- Timber
- Any components of construction materials including Portland cement, aggregates, supplementary cementitious materials, emulsion, industrial by-wastes, etc.
- Development of the optimum mixture design and the sustainable mixture design

2. MECHANICAL TESTS

- Setting time, slump, rheological properties
- All types of strength tests
- Creep tests
- Shrinkage tests (chemical, autogenous, and drying shrinkages)
- Thermal cracking tests
- Restrained shrinkage cracking tests

3. DURABILITY TESTS

- Various chemical attacks (acid attack, sulfate attack, and chloride attack)
- Corrosion potential tests
- Chloride diffusion tests
- Alkali-silica reaction
- Carbonation
- Water absorption

4. CHARACTERISATION OF MATERIALS

- Elemental composition and mineralogical composition of materials
- Materials reactivity as construction materials
- Thermal properties of materials
- Electrical properties
- Microstructure changes
- Pore structural changes

CIES Equipment for Construction Materials Testing

1.1 MECHANICAL PROPERTIES

- Strength testing machines
  - Avery 1800kN Concrete Compression testing machine
  - Satec 3Mn Static compression testing machine
  - INSTRON 10kN Universal testing machine
- Different sizes of mixers
- Flow table tests
- VICAMATIC-20UTCM (Automatic Vicat apparatus for setting time)
- Discovery Hybrid Rheometer – 2 for the rheological properties
- Shrinkage and creep testing apparatus
- Corrugated autogenous shrinkage apparatus (in compliance with ASTM C1698)
  - Apparatus for chemical shrinkage (in compliance with ASTM C1608)
  - Concrete prism drying shrinkage
  - Compressive creep test
  - Tensile creep test
- Rigid cracking frame for thermal cracking of the concrete
- 3D printing robotic arms

1.2 DURABILITY TESTS

- Corrosion tests
  - Chloride bulk diffusion test
  - Rapid chloride penetration test
  - Rapid chloride migration test
  - Robotic titrosampler analysis of the chloride profile in concrete
  - Potentiometer for the corrosion potential measurement (VMP3-01/Z DC +EIC channels)
- Environmental control chambers (humidity and temperature)
- Carbonation chamber
- Glove boxes to control the environments

1.3 CHARACTERISATION OF MATERIALS

- Thermogravimetric analysis (Q600-SDT simultaneous SDC-TGA)
- Thermal diffusivity measurement (LFA-3467 Hyperflaseh)
- Thermal conductivity (Trident C-therm)
- Adsorption and desorption analyzer for pore size distribution and surface area (NOVAtouch NT 4LX)
- Ball mill grinder (Fritsch Pulverisette-6 Mill)
- Mercury Introsion Porosmetry (Micromeritics autopore 9520)
- Ultrasonic pulse velocity measurement (Pundit PL200 Ultrasonic tester)
- Surface electrical resistivity measurement (Proceq concrete resistivity meter)
- Particle size distribution analyzer (Malvern Mastersizer)
- Fourier transformation infrared (FTIR) spectroscopy (PerkinElmer FTIR)
- Concrete pore solution analysis (Pore solution extraction device and Inductively coupled plasma – optical emission spectroscopy)

4. ALL OTHER ANALYTICAL CHARACTERISATION TECHNIQUES ARE AVAILABLE IN MARK WAINWRIGHT ANALYTICAL CENTRE AT UNSW

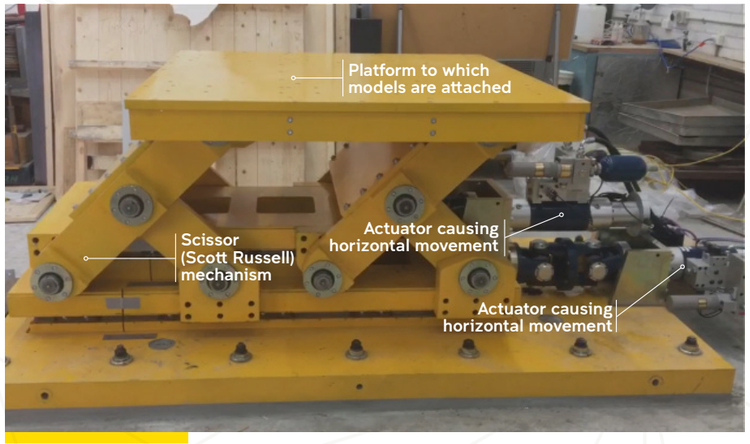
- Scanning electron microscopy – Energy dispersive spectroscopy
- X-ray fluorescence (XRF)
- X-ray diffraction (XRD) facility
- Tyree X-ray CT facility
- Nuclear magnetic resonance (NMR) facility

CIES Geotechnical Engineering Laboratories

Our well-equipped geotechnical engineering laboratories contain a diverse range of soil, rock and asphalt testing equipment, along with specialist and advanced equipment used to support industry-focused research. Our researchers are award-winning and recognised globally as leaders in their field. The scale of our laboratory capability is not available in any other university in Australia.

EQUIPMENT INCLUDES:

- Earthquake shaking table (permitting simultaneous horizontal and vertical motion) and laminated shear stack – 2.6 tonne models http://www.cies.unsw.edu.au/news/earthquake-research-given-a-shake-up
- Calibration chamber for CPT testing (adaptable for pile testing, pressuremeter testing and dilatometertesting) https://www.linkedin.com/feed/update/activity:6422264686678540288/
- 2cm2 cone, Hyson 100kN penetrometer, logging system and calibration chamber for housing large unsaturated soil and tailings samples
- Enterprise level dynamic triaxial testing facility for saturated and unsaturated samples (x2)
- Enterprise level dynamic simple shear testing facility for saturated and unsaturated samples (x1)
- Enterprise level dynamic true triaxial testing facility for saturated and unsaturated samples (x1)
- Consolidometers (CRS and standard) (for testing saturated and unsaturated samples 50100mm diameter) (x 4)
- Slurriometer (for testing saturated and very soft (tailings like) deposits, 50mm diameter) (x 1)
- Resonant column testing facilities for saturated and unsaturated samples (x2)
- Rock triaxial cell for testing samples 25mm, 50mm or 100mm diameter at cell pressures up to 64MPa (x1)
- Bishop Wesley triaxial equipment for testing saturated and unsaturated soils (x 4, including one for testing at elevated temperatures)
- Triaxial cells for saturated soil samples 100mm and 200mm diameters (x 2)
- Standard triaxial cell for testing saturated samples of 50mm diameter (x1)
- Ring shear equipment for assessing residual strength within soil and at interfaces (Bromhead type) (x1)
- Shear boxes (for testing samples 100mm by 100mm) (x 4)
- Large shear box (for testing samples 300mm by 300mm) (x1)
- Lysimeter lights and frames to simulate sun drying
- Lateral earth pressure rig – 3 tonne models
- Shallow foundation testing rig – 2 tonne models
- Soil pressure plates for determining relationship between suction and moisture content (x4)
- Osmotic equipment for determining relationship between suction and moisture content
- Filter paper equipment for determining relationship between suction and moisture content
- Bespoke soil erosion testing equipment (pinhole erosion, suffusion, internal erosion and surface erosion)



Inventory of Major Testing Facilities at Heavy Structures Lab

- A RED Testing Frame with INSTRON 5 MN Compression/Tension actuator for static or low frequency dynamic tests
- A YELLOW Testing Frame with two INSTRON 500 kN Compression/Tension actuators for individual or collaborative static or dynamic/fatigue tests
- A GREEN Testing Frame with one INSTRON 1.2 MN Compression/Tension actuator and one INSTRON 300 kN HORIZONTAL Compression/Tension actuator for individual static or dynamic/fatigue tests
- 1 MN INSTRON Tension/Compression Universal testing machine for static or dynamic/fatigue tests
- 250 kN INSTRON Tension/Compression Universal testing machine for static or dynamic/fatigue tests
- 2 MN INSTRON testing machine for static Compression tests
- A Steel Frame (Gray) with a 2.5 MN compression ram for long term loading tests
- A Steel Frame (Blue) with a 2 MN compression ram for long term loading tests
- A 29.3 x 9.75 x1.22m prestressed reinforced concrete floor area provided a strong structural footing for 3 major testing frames (Red, Yellow and Green) plus quite a few anchor points for setting up small steel frames for short/long term loading tests
- A climate (Temperature and R/H) controlled room with 6+ creep rigs for creep testing
- A 5t overhead bridge crane, a 10m vertical mast Elevated Work Platform (EWP), 2 forklifts (2.5t and 1.5t) and a battery Walkie (1.3t) enabled mobile handling and setting up/disposal of large and heavy specimens
- A VIC-3D DIC (Digital Image Correlation) system enables advanced 2D and 3D strain measurements of specimens during experimental testing

CIES PUBLICATIONS

APA6 Citation. CIES Author/s in bold

Noushini, A., Castel, A., **Aldred, J.**, & Rawal, A. (2020). Chloride diffusion resistance and chloride binding capacity of fly ash-based geopolymer concrete. Cement and Concrete Composites, 105. doi:10.1016/j.cemconcomp.2019.04.006

Chen, L. L., Zhang, Y., Lian, H., **Atroshchenko, E.**, Ding, C., & Bordas, S. P. A. (2020). Seamless integration of computer-aided geometric modeling and acoustic simulation: Isogeometric boundary element methods based on Catmull-Clark subdivision surfaces. Advances in Engineering Software, 149. doi:10.1016/j.advengsoft.2020.102879

Peralta, P., Ruiz, R. O., Natarajan, S., & **Atroshchenko, E.** (2020). Parametric study and shape optimization of Piezoelectric Energy Harvesters by isogeometric analysis and kriging metamodeling. Journal of Sound and Vibration, 484. doi:10.1016/j.jsv.2020.115521

Shaaban, A. M., Anitescu, C., **Atroshchenko, E.**, & Rabczuk, T. (2020). Isogeometric boundary element analysis and shape optimization by PSO for 3D axi-symmetric high frequency Helmholtz acoustic problems. Journal of Sound and Vibration, 486. doi:10.1016/j.jsv.2020.115598

Mathew, T. V., Prajith, P., Ruiz, R. O., **Atroshchenko, E.**, & Natarajan, S. (2020). Adaptive importance sampling based neural network framework for reliability and sensitivity prediction for variable stiffness composite laminates with hybrid uncertainties. Composite Structures, 245. doi:10.1016/j.compstruct.2020.112344

Mostafa Shaaban, A., Anitescu, C., **Atroshchenko, E.**, & Rabczuk, T. (2020). Shape optimization by conventional and extended isogeometric boundary element method with PSO for two-dimensional Helmholtz acoustic problems. Engineering Analysis with Boundary Elements, 113, 156-169. doi:10.1016/j.enganabound.2019.12.012

Videla, J., Contreras, F., Nguyen, H. X., & **Atroshchenko, E.** (2020). Application of PHT-splines in bending and vibration analysis of cracked Kirchhoff“Love plates. Computer Methods in Applied Mechanics and Engineering, 361. doi:10.1016/j.cma.2019.112754

Ayala, T., Videla, J., Anitescu, C., & **Atroshchenko, E.** (2020). Enriched Isogeometric Collocation for two-dimensional time-harmonic acoustics. Computer Methods in Applied Mechanics and Engineering, 365. doi:10.1016/j.cma.2020.113033

Kim, M. Y., Mehdi, A. I., & **Attard, M. M.** (2020). Finite strain theories of extensible and shear-flexible planar beams based on three different hypotheses of member forces. International Journal of Solids and Structures, 193-194, 434-446. doi:10.1016/j.ijsolstr.2020.02.029

Makasis, N., Narsilio, G. A., **Bidarmaghz, A.**, Johnston, I. W., & Zhong, Y. (2020). The importance of boundary conditions on the modelling of energy retaining walls. Computers and Geotechnics, 120. doi:10.1016/j.compgeo.2019.103399

Bidarmaghz, A., Choudhary, R., Soga, K., Terrington, R. L., Kessler, H., & Thorpe, S. (2020). Large-scale urban underground hydro-thermal modelling - A case study of the Royal Borough of Kensington and Chelsea, London. Science of the Total Environment, 700. doi:10.1016/j.scitotenv.2019.134955

Menberg, K., **Bidarmaghz, A.**, Gregory, A., Choudhary, R., & Girolami, M. (2020). Multi-fidelity approach to Bayesian parameter estimation in subsurface heat and fluid transport models. Science of the Total Environment, 745. doi:10.1016/j.scitotenv.2020.140846

Bradford, M. A., Pi, Y. L., & Liu, A. (2020). Closure to "Out-Plane Elastic-Plastic Buckling Strength of High-Strength Steel Arches" by Mark Andrew Bradford, Yong-Lin Pi, and Airong Liu. Journal of Structural Engineering (United States), 146(2). doi:10.1061/(ASCE)ST.1943-541X.0002496

Wang, Y., **Bradford, M. A.**, & Liu, X. (2020). Strength design of welded high-strength steel beams considering coupled local and global buckling. Thin-Walled Structures, 149. doi:10.1016/j.tws.2019.106391

Zhang, Y., Liu, A., Chen, B., Zhang, J., **Pi, Y. L., & Bradford, M. A.** (2020). Experimental and numerical study of shear connection in composite beams of steel and steel-fibre reinforced concrete. Engineering Structures, 215. doi:10.1016/j.engstruct.2020.110707

Huang, Y., Liu, A., **Pi, Y. L., Bradford, M. A.**, & Fu, J. (2020). Experimental and numerical investigations on remaining strengths of damaged parabolic steel tubular arches. Steel and Composite Structures, 34(1), 1-15. doi:10.12989/scs.2020.34.1.00

Le, T., **Bradford, M. A.**, Liu, X., & **Valipour, H. R.** (2020). Buckling of welded high-strength steel I-beams. Journal of Constructional Steel Research, 168. doi:10.1016/j.jcsr.2020.105938

Lu, H., Liu, L., Liu, A., **Pi, Y. L., Bradford, M. A.**, & Huang, Y. (2020). Effects of movement and rotation of supports on nonlinear instability of fixed shallow arches. Thin-Walled Structures, 155. doi:10.1016/j.tws.2020.106909

Nasirzadeh, F., Rostamnezhad, M., **Carmichael, D. G.**, Khosravi, A., & Aisbett, B. (2020). Labour productivity in Australian building construction projects: a roadmap for improvement. International Journal of Construction Management. doi:10.1080/15623599.2020.1765286

Carmichael, D. G. (2020). A framework for a civil engineering systems BOK. Civil Engineering and Environmental Systems, 37(4), 154-165. doi:10.1080/10286608.2020.1815012

Hosseinian, S. M., Farahpour, E., & **Carmichael, D. G.** (2020). An optimum multiple outcomes sharing model with multiple risk-averse agents. Engineering, Construction and Architectural Management. doi:10.1108/ECAM-03-2020-0194

Hosseinian, S. M., Farahpour, E., & **Carmichael, D. G.** (2020). Optimum Outcome-Sharing Construction Contracts with Multiagent and Multioutcome Arrangements. JOURNAL OF CONSTRUCTION ENGINEERING AND MANAGEMENT, 146(7), 12 pages. doi:10.1061/(ASCE)CO.1943-7862.0001862

Carmichael, D. G. (2020). Author’s reply to: David Elms discussion of 'Bias and decision making–an overview systems explanation'. Civil Engineering and Environmental Systems, 37(3), 146-148. doi:10.1080/10286608.2020.1821671

Ullah, F., Sepasgozar, S., Tahmasebinia, F., Sepasgozar, S. M. E., & **Davis, S.** (2020). Examining the impact of students attendance, sketching, visualization, and tutors experience on students’ performance: a case of building structures course in construction management. Construction Economics and Building, 20(3), 78-102. doi:10.5130/AJCEB.v20i3.7056

Eisenträger, J., Zhang, J., Song, C., & Eisenträger, S. (2020). An SBFEM Approach for Rate-Dependent Inelasticity with Application to Image-Based Analysis. International Journal of Mechanical Sciences, 182. doi:10.1016/j.ijmecsci.2020.105778

Petoe, M., Duvigneau, F., & **Eisenträger, S**. (2020). Enhanced numerical integration scheme based on image-compression techniques: application to fictitious domain methods. Advanced Modeling and Simulation in Engineering Sciences, 7(1). doi:10.1186/s40323-020-00157-2

Eisenträger, S.., Atroshchenko, E., & Makvandi, R. (2020). On the condition number of high order finite element methods: Influence of p-refinement and mesh distortion. Computers and Mathematics with Applications, 80(11), 2289-2339. doi:10.1016/j.camwa.2020.05.012

Eisenträger, S., Saputra, A. A., & Gravenkamp, H. (2020). High order transition elements: The xNy-element concept–Part I: Statics. Computer Methods in Applied Mechanics and Engineering, 362. doi:10.1016/j.cma.2020.112833

Petoe, M., Duvigneau, F., Juhre, D., & **Eisentrager, S.** (2020). Enhanced numerical integration scheme based on image compression techniques: Application to rational polygonal interpolants. ARCHIVE OF APPLIED MECHANICS, 91(2), 753-775. doi:10.1007/s00419-020-01772-6

Miletić, M., Kumar, L. M., Arns, J. Y., Agarwal, A., **Foster, S. J.**, Arns, C., & Perić, D. (2020). Gradient-based fibre detection method on 3D micro-CT tomographic image for defining fibre orientation bias in ultra-high-performance concrete. Cement and Concrete Research, 129. doi:10.1016/j.cemconres.2019.105962

Mahmood, A. H., Foster, S. J., & Castel, A. (2020). Development of high-density geopolymer concrete with steel furnace slag aggregate for coastal protection structures. Construction and Building Materials, 248. doi:10.1016/j.conbuildmat.2020.118681

Mahmood, A. H., Foster, S. J., & Castel, A. (2020). High-density geopolymer concrete for Port Kembla breakwater upgrade. Construction and Building Materials, 262. doi:10.1016/j.conbuildmat.2020.120920

Tong, G. S., Pi, Y. L., & **Gao, W.** (2020). In-plane nonlinear analysis and buckling of shear-deformable circular arches. Advanced Steel Construction, 16(1), 55-64. doi:10.18057/IJASC.2020.16.1.7

Feng, Y., Wu, D., Liu, L., **Gao, W., & Tin-Loi, F.** (2020). Safety assessment for functionally graded structures with material nonlinearity. Structural Safety, 86. doi:10.1016/j.strusafe.2020.101974

Li, Q., Wu, D., **Gao, W., & Tin-Loi, F.** (2020). Size-dependent instability of organic solar cell resting on Winkler–Pasternak elastic foundation based on the modified strain gradient theory. International Journal of Mechanical Sciences, 177. doi:10.1016/j.ijmecsci.2019.105306

Wang, Q., Li, Q., Wu, D., **Yu, Y., Tin-Loi, F.**, Ma, J., & **Gao, W.** (2020). Machine learning aided static structural reliability analysis for functionally graded frame structures. Applied Mathematical Modelling, 78, 792-815. doi:10.1016/j.apm.2019.10.007

Li, W., **Gao, W.**, & Chen, S. (2020). A material-based higher-order shear beam model for accurate analyses of FG beams with arbitrary material distribution. Composite Structures, 245. doi:10.1016/j.compstruct.2020.112253

Feng, Y., Wang, Q., Wu, D., **Gao, W., & Tin-Loi, F.** (2020). Stochastic nonlocal damage analysis by a machine learning approach. Computer Methods in Applied Mechanics and Engineering, 372. doi:10.1016/j.cma.2020.113371

Ma, J., Liu, B., Wriggers, P., **Gao, W.**, & Yan, B. (2020). The dynamic analysis of stochastic thin-walled structures under thermal–structura–acoustic coupling. Computational Mechanics, 65(3), 609-634. doi:10.1007/s00466-019-01786-0

Lian, X., Dai, H., **Ge, L.**, & Cai, Y. (2020). Assessment of a house affected by ground movement using terrestrial laser scanning and numerical modeling. Environmental Earth Sciences, 79(9). doi:10.1007/s12665-020-08929-0

Du, Z., **Ge, L.**, Ng, A. H. M., Zhu, Q., Horgan, F. G., & Zhang, Q. (2020). Risk assessment for tailings dams in Brumadinho of Brazil using InSAR time series approach. Science of the Total Environment, 717. doi:10.1016/j.scitotenv.2020.137125

Dai, Y., Ng, A. H. -M., Wang, H., Li, L., **Ge, L.**, & Tao, T. (2020). Modeling-Assisted InSAR Phase-Unwrapping Method for Mapping Mine Subsidence. IEEE Geoscience and Remote Sensing Letters, 1-5. doi:10.1109/lgrs.2020.2991687

Du, Z., **Ge, L.**, Ng, A. H. M., & Zhang, Q. (2020). Towards a revised framework of modified time series InSAR for mapping land deformation. Journal of Geodesy, 94(9). doi:10.1007/s00190-020-01419-y

Mazumder, M. H., **Gilbert, R. I.**, & Chang, Z. T. (2020). Anchorage length of reinforcing bars in tension: an assessment of the Australian Standard AS 3600:2018. Asian Journal of Civil Engineering, 21(3), 411-420. doi:10.1007/s42107-019-00216-z

Bernard, E. S., Amin, A., & **Gilbert, R. I**. (2020). Assessment of MC2010 and AS3600 models for estimating instantaneous flexural crack widths in fibre reinforced concrete members. Engineering Structures, 208. doi:10.1016/j.engstruct.2020.110271

Watts, M. J., Amin, A., **Gilbert, R. I.**, & Kaufmann, W. (2020). Behavior of fiber reinforced concrete members under sustained axial/flexural load. Structural Concrete, 21(4), 1441-1457. doi:10.1002/suco.201900227

Watts, M. J., Amin, A., **Gilbert, R. I.**, Kaufmann, W., & Minelli, F. (2020). Simplified prediction of the time dependent deflection of SFRC flexural members. Materials and Structures/Materiaux et Constructions, 53(3). doi:10.1617/s11527-020-01479-8

Khan, I., Xu, T., Khan, M. S. H., Castel, A., & **Gilbert, R. I.** (2020). Effect of Various Supplementary Cementitious Materials on Early-Age Concrete Cracking. Journal of Materials in Civil Engineering, 32(4). doi:10.1061/(ASCE)MT.1943-5533.0003120

Delhomme, F., **Hajimohammadi, A.**, Almeida, A., Jiang, C., Moreau, D., Gan, Y., . . . Castel, A. (2020). Physical properties of Australian hurd used as aggregate for hemp concrete. Materials Today Communications, 24. doi:10.1016/j.mtcomm.2020.100986

Huang, Q., **Hamed, E., & Gilbert, R. I.** (2020). Early-age shrinkage effects in precast concrete sandwich panels. PCI Journal, 65(1), 74-88.

Chen, J., **Hamed, E., & Ian Gilbert, R.** (2020). Structural Performance of Reinforced Concrete Walls under Fire Conditions. Journal of Structural Engineering (United States), 146(3). doi:10.1061/(ASCE)ST.1943-541X.0002519

Zhang, S., & **Hamed, E.** (2020). Application of various creep analysis methods for estimating the time-dependent behavior of cracked concrete beams. Structures, 25, 127-137. doi:10.1016/j.istruc.2020.02.029

Huang, Q., **Hamed, E., & Gilbert, R. I.** (2020). Behavior of Concrete Sandwich Panels under Eccentric Axial Compressionâ€"Testing and Finite Element Analysis. ACI Structural Journal, 117(3), 235-247. doi:10.14359/51723502

Huang, Q., **Hamed, E., & Gilbert, I.** (2020). Experimental and numerical investigation of the creep response of precast concrete sandwich panels. Structures, 28, 2096-2110. doi:10.1016/j.istruc.2020.10.039

Hamed, E., & Frostig, Y. (2020). Nonlinear thermo-mechanical behaviour of soft core sandwich panels â€“ Creep effects. Journal of Sandwich Structures and Materials, 22(8), 2629-2654. doi:10.1177/1099636218807727

Hamed, E., Huang, Q., & **Gilbert, R. I.** (2020). Testing of Prefabricated-Concrete Sandwich Panels made with Diagonal-Bar Shear Connectors. Concrete in Australia, 46(1), 31-35.

Gupta, S., Krishnan, P., **Kashani, A.**, & Kua, H. W. (2020). Application of biochar from coconut and wood waste to reduce shrinkage and improve physical properties of silica fume-cement mortar. Construction and Building Materials, 262. doi:10.1016/j.conbuildmat.2020.120688

Kashani, A., Ngo, T. D., Nguyen, T. N., **Hajimohammadi, A.**, Sinaie, S., & Mendis, P. (2020). The effects of surfactants on properties of lightweight concrete foam. Magazine of Concrete Research, 72(4), 163-172. doi:10.1680/jmacr.18.00242

Salimzadeh, S., Zimmerman, R. W., & **Khalili, N.** (2020). Gravity Hydraulic Fracturing: A Method to Create Self-Driven Fractures. Geophysical Research Letters, 47(20). doi:10.1029/2020GL087563

Khoshini, M., **Khoshghalb, A.**, Henwood, S., & **Khalili, N.** (2020). The strenuous leura weak sandstone. Australian Geomechanics Journal, 55(2), 107-119.

Jia, P., **Khoshghalb, A.**, Chen, C., Zhao, W., Dong, M., & Alipour Esgandani, G. (2020). Modified Duncan-Chang Constitutive Model for Modeling Supported Excavations in Granular Soils. International Journal of Geomechanics, 20(11). doi:10.1061/(ASCE)GM.1943-5622.0001848

Oluwatuyi, O. E., Ojuri, O. O., & **Khoshghalb, A**. (2020). Cement-lime stabilization of crude oil contaminated kaolin clay. Journal of Rock Mechanics and Geotechnical Engineering, 12(1), 160-167. doi:10.1016/j.jrmge.2019.07.010

Jia, P., Zhao, W., **Khoshghalb, A.**, Ni, P., Jiang, B., Chen, Y., & Li, S. (2020). A new model to predict ground surface settlement induced by jacked pipes with flanges. Tunnelling and Underground Space Technology, 98. doi:10.1016/j.tust.2020.103330

Pasha, A., **Khoshghalb, A., & Khalili, N.** (2020). Evolution of isochoric water retention curve with void ratio. Computers and Geotechnics, 122. doi:10.1016/j.compgeo.2020.103536

Khoshghalb, A., Shafee, A., Tootoonchi, A., Ghaffaripour, O., & Jazaeri, S. A. (2020). Application of the smoothed point interpolation methods in computational geomechanics: A comparative study. Computers and Geotechnics, 126. doi:10.1016/j.compgeo.2020.103714

Panchmatia, P., **Kim, T.**, & Olek, J. (2020). Effects of Air-Cooled Blast Furnace Slag Aggregate on Pore Solution Chemistry of Cementitious Systems. Journal of Materials in Civil Engineering, 32(1), 0401937. doi:10.1061/(ASCE)MT.1943-5533.0002960

Kang, S., Tyler Ley, M., Lloyd, Z., & **Kim, T**. (2020). Using the Particle Model to predict electrical resistivity performance of fly ash in concrete. Construction and Building Materials, 261. doi:10.1016/j.

conbuildmat.2020.119975

Nguyen, Q. D., **Kim, T.**, & Castel, A. (2020). Mitigation of alkali-silica reaction by limestone calcined clay cement (LC3). Cement and Concrete Research, 137. doi:10.1016/j.cemconres.2020.106176

Kang, S., Lloyd, Z., **Kim, T.**, & Ley, M. T. (2020). Predicting the compressive strength of fly ash concrete with the Particle Model. Cement and Concrete Research. doi:10.1016/j.cemconres.2020.106218

Kim, T., Ley, M. T., Kang, S., Davis, J. M., Kim, S., & Amrollahi, P. (2020). Using particle composition of fly ash to predict concrete strength and electrical resistivity. Cement and Concrete Composites, 107, 103493. doi:10.1016/j.cemconcomp.2019.103493

Alnahhal, M. F., **Kim, T., & Hajimohammadi, A.** (2020). Evolution of flow properties, plastic viscosity, and yield stress of Alkali-activated fly ash/slag pastes. RILEM Technical Letters, 5, 141-149. doi:10.21809/rilemtechlett.2020.123

Mahmood, A. H., Foster, S. J., & Castel, A. (2020). High-density geopolymer concrete for Port Kembla breakwater upgrade. Construction and Building Materials, 262. doi:10.1016/j.conbuildmat.2020.120920

Mahmood, A. H., Foster, S. J., & Castel, A. (2020). Development of high-density geopolymer concrete with steel furnace slag aggregate for coastal protection structures. Construction and Building Materials, 248. doi:10.1016/j.conbuildmat.2020.118681

Kildashti, K., **Makki Alamdari, M.**, Kim, C. W., **Gao, W.**, & Samali, B. (2020). Drive-by-bridge inspection for damage identification in a cable-stayed bridge: Numerical investigations. Engineering Structures, 223. doi:10.1016/j.engstruct.2020.110891

Lin, S. T. K., Lu, Y., **Alamdari, M. M.**, & Khoa, N. L. D. (2020). Field test investigations for condition monitoring of a concrete culvert bridge using vibration responses. Structural Control and Health Monitoring, 27(10). doi:10.1002/stc.2614

Kalhori, H., **Alamdari, M. M.**, Li, B., Halkon, B., Hosseini, S. M., Ye, L., & Li, Z. (2020). Concurrent Identification of Impact Location and Force Magnitude on a Composite Panel. International Journal of Structural Stability and Dynamics, 20(10). doi:10.1142/S0219455420420043

Hong, Y., Hammad, A. W. A., **Akbarnezhad, A.**, & Arashpour, M. (2020). A neural network approach to predicting the net costs associated with BIM adoption. Automation in Construction, 119. doi:10.1016/j.autcon.2020.103306

Hammad, A. W., Grzybowska, H., Sutrisna, M., **Akbarnezhad, A.**, & Haddad, A. (2020). A novel mathematical optimisation model for the scheduling of activities in modular construction factories. Construction Management and Economics, 38(6), 534-551. doi:10.1080/01446193.2019.1682174

Hong, Y., Hammad, A., Zhong, X., Wang, B., & **Akbarnezhad, A.** (2020). Comparative Modeling Approach to Capture the Differences in BIM Adoption Decision-Making Process in Australia and China. Journal of Construction Engineering and Management, 146(2). doi:10.1061/(ASCE)CO.1943-7862.0001746

Mesgari, S., **Akbarnezhad, A.**, & Xiao, J. Z. (2020). Recycled geopolymer aggregates as coarse aggregates for Portland cement concrete and geopolymer concrete: Effects on mechanical properties. Construction and Building Materials, 236. doi:10.1016/j.conbuildmat.2019.117571

Chen, Z., Hammad, A. W. A., Kamardeen, I., & **Akbarnezhad, A.** (2020). Optimising embodied energy and thermal performance of thermal insulation in building envelopes via an automated building information modelling (BIM) tool. Buildings, 10(12), 1-23. doi:10.3390/buildings10120218

Khan, M. S. H., **Nguyen, Q. D.**, & Castel, A. (2020). Performance of limestone calcined clay blended cement-based concrete against carbonation. Advances in Cement Research, 32(11), 481-491. doi:10.1680/jadcr.18.00172

Nguyen, Q. D., Khan, M. S. H., & Castel, A. (2020). Chloride Diffusion in Limestone Flash Calcined Clay Cement Concrete. ACI Materials Journal, 117(6). doi:10.14359/51725987

Nguyen, Q. D., Khan, M. S. H., & Castel, A. (2020). Chloride Diffusion in Limestone Flash Calcined Clay Cement Concrete. ACI MATERIALS JOURNAL, 117(6), 165-175. doi:10.14359/51725986

Nguyen, Q. D., & Castel, A. (2020). Reinforcement corrosion in limestone flash calcined clay cement-based concrete. Cement and Concrete Research, 132. doi:10.1016/j.cemconres.2020.106051

O'Shea, D. J., Attard, M. M., & Kellermann, D. C. (2020). Anisotropic hyperelasticity using a fourth-order structural tensor approach. International Journal of Solids and Structures, 198, 149-169. doi:10.1016/j.ijsolstr.2020.03.021

O'Shea, D. J., Attard, M. M., Kellermann, D. C., & Sansour, C. (2020). Nonlinear finite element formulation based on invariant-free hyperelasticity for orthotropic materials. International Journal of Solids and Structures, 185-186, 191-201. doi:10.1016/j.ijsolstr.2019.08.010

Jiang, Z. Q., Yang, X. F., Dou, C., **Pi, Y. L.**, & Li, R. (2020). Design theory of earthquake-resilient prefabricated beam-column steel joint with double flange cover plates. Engineering Structures, 209. doi:10.1016/j.engstruct.2019.110005

Pi, Y. L. (2020). Non-linear in-plane multiple equilibria and buckling of pin-ended shallow circular arches under an arbitrary radial point load. Applied Mathematical Modelling, 77, 115-136. doi:10.1016/j.apm.2019.07.021

Zhu, B. L., Guo, Y. L., Zhou, P., & **Pi, Y. L.** (2020). Load-carrying performance and design of BRBs confined with longitudinal shuttle-shaped-trusses. Journal of Constructional Steel Research, 167. doi:10.1016/j.jcsr.2020.105954

Zhu, B. L., Zhou, P., Guo, Y. L., Zhu, J. S., & **Pi, Y. L.** (2020). Load resistance and hysteretic response of shuttle-shaped truss-confined BRBs. Engineering Structures, 208. doi:10.1016/j.engstruct.2019.109599

Zhang, Z., Liu, A., Yang, J., **Pi, Y. L.**, Huang, Y., & Fu, J. (2020). A theoretical and experimental study on in-plane buckling of orthotropic composite arches under an arbitrary radial point load. Composite Structures, 237. doi:10.1016/j.compstruct.2020.111933

Tong, J. Z., Pan, W. H., & **Pi, Y. L.** (2020). Exact solutions for second-order effect of imperfect beams and frames based on matrix structural analysis. Structures, 23, 677-689. doi:10.1016/j.istruc.2019.12.001

Zhu, J. S., Guo, Y. L., Wang, M. Z., Yang, X., & **Pi, Y. L.** (2020). Seismic performance of concrete-infilled double steel corrugated-plate walls: Experimental research. Engineering Structures, 215. doi:10.1016/j.engstruct.2020.110601

Zhu, B. L., Guo, Y. L., Gao, J. K., & **Pi, Y. L.** (2020). Behaviour and design of spatial triple-truss-confined BRBs with a longitudinal shuttle shape. Engineering Structures, 215. doi:10.1016/j.engstruct.2020.110605

Yang, Z., Liu, A., **Pi, Y. L.**, Fu, J., & Gao, Z. (2020). Nonlinear dynamic buckling of fixed shallow arches under impact loading: An analytical and experimental study. Journal of Sound and Vibration, 487. doi:10.1016/j.jsv.2020.115622

Vo, T., & **Russell, A. R.** (2020). Contours of saturated and unsaturated overhanging slopes at limiting equilibrium condition. International Journal for Numerical and Analytical Methods in Geomechanics, 44(1), 93-116. doi:10.1002/nag.3008

Li, S., **Russell, A. R.**, & Wood, D. M. (2020). Influence of particle-size distribution homogeneity on shearing of soils subjected to internal erosion. Canadian Geotechnical Journal, 57(11), 1684-1694. doi:10.1139/cgj-2019-0273

Zhang, X., & **Russell, A. R.** (2020). Assessing Liquefaction Resistance of Fiber-Reinforced Sand Using a New Pore Pressure Ratio. Journal of Geotechnical and Geoenvironmental Engineering, 146(1). doi:10.1061/(ASCE)GT.1943-5606.0002197

Gravenkamp, H., **Saputra, A. A.**, & **Eisenträger, S.** (2020). Three-dimensional image-based modeling by combining SBFEM and transfinite element shape functions. Computational Mechanics, 66(4), 911-930. doi:10.1007/s00466-020-01884-4

Saputra, A. A., Eisenträger, S, Gravenkamp, H., & **Song, C.** (2020). Three-dimensional image-based numerical homogenisation using octree meshes. Computers and Structures, 237. doi:10.1016/j.compstruc.2020.106263

Zhang, Z., Zhou, C., **Saputra, A.**, Yang, Z., & **Song, C.** (2020). Nonlocal dynamic damage modelling of quasi-brittle composites using the scaled boundary finite element method. Engineering Fracture Mechanics, 240. doi:10.1016/j.engfracmech.2020.107362

Ooi, E. T., **Saputra, A.**, Natarajan, S., Ooi, E. H., & **Song, C.** (2020). A dual scaled boundary finite element formulation over arbitrary faceted star convex polyhedra. Computational Mechanics, 66(1), 27-47. doi:10.1007/s00466-020-01839-9

Moghaddasi, H., **Shahbodagh, B., & Khalili, N.** (2020). Lateral Vibration of Piles and Pile Groups in Nonhomogeneous Transversely Isotropic Media. International Journal of Geomechanics, 20(8). doi:10.1061/(ASCE)GM.1943-5622.0001753

Shahbodagh, B., Mac, T. N., Esgandani, G. A., & **Khalili, N.** (2020). A Bounding Surface Viscoplasticity Model for Time-Dependent Behavior of Soils including Primary and Tertiary Creep. International Journal of Geomechanics, 20(9). doi:10.1061/(ASCE)GM.1943-5622.0001744

Shahbodagh, B., Sadeghi, H., Kimoto, S., & Oka, F. (2020). Large deformation and failure analysis of river embankments subjected to seismic loading. Acta Geotechnica, 15(6), 1381-1408. doi:10.1007/s11440-019-00861-3

Dong, M., Wang, L., **Shahbodagh, B.**, Du, X., Deng, S., & Sun, Z. (2020). Effect of the soft and hard interbedded layers of bedrock on the mechanical characteristics of stabilizing piles. Applied Sciences (Switzerland), 10(14). doi:10.3390/app10144760

Liu, L., Lim, S., **Shen, X.**, & Yebra, M. (2020). Assessment of generalized allometric models for aboveground biomass estimation: A case study in Australia. Computers and Electronics in Agriculture, 175. doi:10.1016/j.compag.2020.105610

Li, B., Zhao, K., & **Shen, X.** (2020). Dilution of precision in positioning systems using both angle of arrival and time of arrival measurements. IEEE Access, 8, 192506-192516. doi:10.1109/ACCESS.2020.3033281

Leng, S., Lin, J. R., Hu, Z. Z., & **Shen, X.** (2020). A Hybrid Data Mining Method for Tunnel Engineering Based on Real-Time Monitoring Data from Tunnel Boring Machines. IEEE Access, 8, 90430-90449. doi:10.1109/ACCESS.2020.2994115

Wang, Y., Liu, J., Wang, J., Zeng, Q., **Shen, X.**, & Zhang, Y. (2020). Micro Aerial Vehicle Navigation with Visual-Inertial Integration Aided by Structured Light. Journal of Navigation, 73(1), 16-36. doi:10.1017/S0373463319000511

Guo, Y., He, J., Jiang, H., Zhou, Y., Jin, F., & **Song, C.** (2020). A simple approach for generating random aggregate model of concrete based on Laguerre tessellation and its application analyses. Materials, 13(17). doi:10.3390/ma13173896

Garg, N., Chakladar, N. D., Prusty, B. G., **Song, C.**, & Phillips, A. W. (2020). Modelling of laminated composite plates with weakly bonded interfaces using scaled boundary finite element method. International Journal of Mechanical Sciences, 170. doi:10.1016/j.ijmecsci.2019.105349

Garg, N., Prusty, B. G., **Song, C.**, & Phillips, A. W. (2020). Cylindrical bending of thick laminated composite plates using scaled boundary finite element method. Engineering Analysis with Boundary Elements, 120, 73-81. doi:10.1016/j.enganabound.2020.08.009

Natarajan, S., Dharmadhikari, P., Annabattula, R. K., Zhang, J., Ooi, E. T., & **Song, C.** (2020). Extension of the scaled boundary finite element method to treat implicitly defined interfaces without enrichment. Computers and Structures, 229. doi:10.1016/j.compstruc.2019.106159

Ooi, E. T., Iqbal, M. D., Birk, C., Natarajan, S., Ooi, E. H., & **Song, C.** (2020). A polygon scaled boundary finite element formulation for transient coupled thermoelastic fracture problems. Engineering Fracture Mechanics, 240. doi:10.1016/j.engfracmech.2020.107300

Huo, S. H., Liu, G. R., **Zhang, J. Q., & Song, C.** (2020). A smoothed finite element method for octree-based polyhedral meshes with large number of hanging nodes and irregular elements. Computer Methods in Applied Mechanics and Engineering, 359. doi:10.1016/j.cma.2019.112646

Li, J., Shi, Z., Liu, L., & **Song, C.** (2020). An efficient scaled boundary finite element method for transient vibro-acoustic analysis of plates and shells. Computers and Structures, 231. doi:10.1016/j.compstruc.2020.106211

Mellati, A., Tangaramvong, S., **Tin-Loi, F., & Song, C.** (2020). An iterative elastic SBFE approach for collapse load analysis of inelastic structures. Applied Mathematical Modelling, 81, 320-341. doi:10.1016/j.apm.2019.12.015

Garg, N., Prusty, B. G., Ooi, E. T., **Song, C.**, Pearce, G., & Phillips, A. W. (2020). Application of scaled boundary finite element method for delamination analysis of composite laminates using cohesive zone modelling. Composite Structures, 253. doi:10.1016/j.compstruct.2020.112773

Gravenkamp, H., **Song, C., & Zhang, J.** (2020). On mass lumping and explicit dynamics in the scaled boundary finite element method. Computer Methods in Applied Mechanics and Engineering, 370. doi:10.1016/j.cma.2020.113274

Liu, L., **Zhang, J., Song, C.**, He, K., **Saputra, A. A., & Gao, W.** (2020). Automatic scaled boundary finite element method for three-dimensional elastoplastic analysis. International Journal of Mechanical Sciences, 171. doi:10.1016/j.ijmecsci.2019.105374

Vahab, M., & Khalili, N. (2020). Empirical and Conceptual Challenges in Hydraulic Fracturing with Special Reference to the Inflow. International Journal of Geomechanics, 20(3). doi:10.1061/(ASCE)GM.1943-5622.0001545

Nouri, F., & **Valipour, H. R.** (2020). Moment-rotation model for steel-timber composite connections with slab continuity steel rods. Journal of Constructional Steel Research, 173. doi:10.1016/j.jcsr.2020.106257

Ghanbari-Ghazijahani, T., Russo, T., & **Valipour, H. R.** (2020). Lightweight timber I-beams reinforced by composite materials. Composite Structures, 233. doi:10.1016/j.compstruct.2019.111579

Keipour, N., **Valipour, H. R., & Bradford, M. A.** (2020). Structural behaviour of steel-timber versus steel-concrete composite joints with flush end plate. Construction and Building Materials, 262. doi:10.1016/j.conbuildmat.2020.120885

Hassanieh, A., & Valipour, H. (2020). Experimental and numerical study of OSB sheathed-LVL stud wall with stapled connections. Construction and Building Materials, 233. doi:10.1016/j.conbuildmat.2019.117373

Masoumi, S., Ebrahimi, D., **Valipour, H.**, & Abdolhosseini Qomi, M. J. (2020). Nanolayered attributes of calcium-silicate-hydrate gels. Journal of the American Ceramic Society, 103(1), 541-557. doi:10.1111/jace.16750

Yu, Y., Gao, W., Castel, A., Liu, A., Chen, X., & Liu, M. (2020). Assessing external sulfate attack on thin-shell artificial reef structures under uncertainty. Ocean Engineering, 207. doi:10.1016/j.oceaneng.2020.107397

Yu, Y., Wu, D., & Gao, W. (2020). Stochastic chemo-physical-mechanical degradation analysis on hydrated cement under acidic environments. Applied Mathematical Modelling, 78, 75-97. doi:10.1016/j.apm.2019.10.012

Yu, Y., Gao, W., Castel, A., Liu, A., Feng, Y., Chen, X., & Mukherjee, A. (2020). Modelling steel corrosion under concrete non-uniformity and structural defects. Cement and Concrete Research, 135. doi:10.1016/j.cemconres.2020.106109

Zhang, J., Eisenträger, J., Eisenträger, S., & Song, C. (2020). Discrete modeling of fiber reinforced composites using the scaled boundary finite element method. Composite Structures, 235. doi:10.1016/j.compstruct.2019.111744

Zhang, J., Natarajan, S., Ooi, E. T., & **Song, C.** (2020). Adaptive analysis using scaled boundary finite element method in 3D. Computer Methods in Applied Mechanics and Engineering, 372. doi:10.1016/j.cma.2020.113374

Tafsirojjaman, T., Fawzia, S., Thambiratnam, D. P., & **Zhao, X. L.** (2020). Study on the cyclic bending behaviour of CFRP strengthened full-scale CHS members. Structures, 28, 741-756. doi:10.1016/j.istruc.2020.09.015

Alam, M. I., Fawzia, S., **Zhao, X. L.**, & M. Remennikov, A. (2020). Numerical modeling and performance assessment of frp-strengthened full-scale circular-hollow-section steel columns subjected to vehicle collisions. Journal of Composites for Construction, 24(3). doi:10.1061/(ASCE)CC.1943-5614.0001011

Bazli, M., Jafari, A., Ashrafi, H., **Zhao, X. L.**, Bai, Y., & Singh Raman, R. K. (2020). Effects of UV radiation, moisture and elevated temperature on mechanical properties of GFRP pultruded profiles. Construction and Building Materials, 231. doi:10.1016/j.conbuildmat.2019.117137

Khaneghahi, M. H., Najafabadi, E. P., Bazli, M., Vatani Oskouei, A., & **Zhao, X. L.** (2020). The effect of elevated temperatures on the compressive section capacity of pultruded GFRP profiles. Construction and Building Materials, 249. doi:10.1016/j.conbuildmat.2020.118725

Li, Y. L., **Zhao, X. L.**, & Raman, R. S. (2020). Durability of seawater and sea sand concrete and seawater and sea sand concreteâ€"filled fibre-reinforced polymer/stainless steel tubular stub columns. Advances in Structural Engineering. doi:10.1177/1369433220944509

Bazli, M., **Zhao, X. L.**, Singh Raman, R. K., Bai, Y., & Al-Saadi, S. (2020). Bond performance between FRP tubes and seawater sea sand concrete after exposure to seawater condition. Construction and Building Materials, 265. doi:10.1016/j.conbuildmat.2020.120342

Bazli, M., Li, Y. L., **Zhao, X. L.**, Raman, R. K. S., Bai, Y., Al-Saadi, S., & Haque, A. (2020). Durability of seawater and sea sand concrete filled filament wound FRP tubes under seawater environments. Composites Part B: Engineering, 202. doi:10.1016/j.compositesb.2020.108409

Bazli, M., **Zhao, X. L.**, Jafari, A., Ashrafi, H., Raman, R. S., Bai, Y., & Khezrzadeh, H. (2020). Durability of glass-fibre-reinforced polymer composites under seawater and sea-sand concrete coupled with harsh outdoor environments. Advances in Structural Engineering. doi:10.1177/1369433220947897

Dong, Z., Wu, G., **Zhao, X. L.**, Zhu, H., Wei, Y., & Yan, Z. (2020). Mechanical properties of discrete BFRP needles reinforced seawater sea-sand concrete-filled GFRP tubular stub columns. Construction and Building Materials, 244. doi:10.1016/j.conbuildmat.2020.118330

Ding, C., Bai, Y., Qiu, C., Wan, C., & **Zhao, X. L.** (2020). Steel bolted flanged connections in tension: Effects of stiffener configurations. Thin-Walled Structures, 154. doi:10.1016/j.tws.2020.106824

Xu, G., Tong, L., **Zhao, X. L.**, Zhou, H., & Xu, F. (2020). Numerical analysis and formulae for SCF reduction coefficients of CFRP-strengthened CHS gap K-joints. Engineering Structures, 210. doi:10.1016/j.engstruct.2020.110369

Li, W., Cheng, Y. F., Wang, D., Han, L. H., & **Zhao, X. L.** (2020). Behaviour of high-strength CFDST chord to CHS brace T-joint: Experiment. Engineering Structures, 219. doi:10.1016/j.engstruct.2020.110780

Bazli, M., **Zhao, X. L.**, Jafari, A., Ashrafi, H., Bai, Y., Singh Raman, R. K., & Khezrzadeh, H. (2020). Mechanical properties of pultruded GFRP profiles under seawater sea sand concrete environment coupled with UV radiation and moisture. Construction and Building Materials, 258. doi:10.1016/j.conbuildmat.2020.120369

Tong, L., Yu, Q., & **Zhao, X. L.** (2020). Experimental study on fatigue behavior of butt-welded thin-walled steel plates strengthened using CFRP sheets. Thin-Walled Structures, 147. doi:10.1016/j.tws.2019.106471

Dong, Z., Wu, G., Zhu, H., **Zhao, X. L.**, Wei, Y., & Qian, H. (2020). Flexural behavior of seawater sea-sand coral concreteâ€“UHPC composite beams reinforced with BFRP bars. Construction and Building Materials, 265. doi:10.1016/j.conbuildmat.2020.120279

Amraei, M., Afkhami, S., Javaheri, V., Larkiola, J., Skriko, T., Björk, T., & **Zhao, X. L.** (2020). Mechanical properties and microstructural evaluation of the heat-affected zone in ultra-high strength steels. Thin-Walled Structures, 157. doi:10.1016/j.tws.2020.107072

Ma, D. Y., Han, L. H., **Zhao, X. L.**, & Yang, W. B. (2020). Seismic performance of the concrete-encased CFST column to RC beam joints: Analytical study. Steel and Composite Structures, 36(5), 533-551. doi:10.12989/scs.2020.36.5.533

Huang, F., Cheng, B., Li, C., & **Zhao, X. L**. (2020). Fatigue behavior of bird-beak SHS X-joints under cyclic brace axial forces. Journal of Constructional Steel Research, 169. doi:10.1016/j.jcsr.2020.106021

Li, Y. L., **Zhao, X. L.**, & Singh Raman, R. K. (2020). Behaviour of seawater and sea sand concrete filled FRP square hollow sections. Thin-Walled Structures, 148. doi:10.1016/j.tws.2019.106596

Dong, Z., Wu, G., **Zhao, X. L.**, Zhu, H., & Lian, J. L. (2020). The durability of seawater sea-sand concrete beams reinforced with metal bars or non-metal bars in the ocean environment. Advances in Structural Engineering, 23(2), 334-347. doi:10.1177/1369433219870580

Tafsirojjaman, T., Fawzia, S., Thambiratnam, D., & **Zhao, X. L.** (2020). Numerical investigation of CFRP strengthened RHS members under cyclic loading. Structures, 24, 610-626. doi:10.1016/j.istruc.2020.01.041

Bazli, M., **Zhao, X. L.**, Bai, Y., Singh Raman, R. K., Al-Saadi, S., & Haque, A. (2020). Durability of pultruded GFRP tubes subjected to seawater sea sand concrete and seawater environments. Construction and Building Materials, 245. doi:10.1016/j.conbuildmat.2020.118399

Cheng, B., Huang, F., Li, C., Duan, Y., & **Zhao, X. L.** (2020). Hot spot stress and fatigue behavior of bird-beak SHS X-joints subjected to brace in-plane bending. Thin-Walled Structures, 150. doi:10.1016/j.tws.2020.106701

Li, Y. L., & **Zhao, X. L.** (2020). Hybrid double tube sections utilising seawater and sea sand concrete, FRP and stainless steel. Thin-Walled Structures, 149. doi:10.1016/j.tws.2020.106643

Amraei, M., **Zhao, X. L.**, Björk, T., & Heidarpour, A. (2020). Bond characteristics between high/ultra-high strength steel and ultra-high modulus CFRP laminates. Engineering Structures, 205. doi:10.1016/j.engstruct.2019.110094