2021 Annual Report
Acknowledgment

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The Australian Research Council (ARC) Industrial Transformation Research Hub for Nanoscience-based Construction Material Manufacturing (the Nanocomm Hub) is a multidisciplinary Research Hub for the construction materials industry. Led out of Monash University in Victoria, the Hub is a network of 13 Australian and three overseas universities and 47 industry partners across Australia, New Zealand, China, Singapore and South Korea. The Hub explores the construction materials industry to inspire technological innovation throughout the sector with the overarching goal of creating lighter, more resilient materials, ultimately contributing to a more efficient, sustainable and liveable Australia.
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CARBON CAPTURE AND UTILISATION
HIGH ON HUB AGENDA

As you may know, the building and construction sector pumps out ~39% of the world’s carbon emissions. The energy used to heat, cool and light buildings, as well as construction processes and the billions of tonnes of materials produced each year, are to blame. And this heavy carbon footprint has accelerated climate change.
with devastating consequences, including Australia’s recent once-in-a-century bushfire and flood events.

The Paris Agreement, with its target of net-zero emissions by 2050, has galvanised the Hub to do its part. We also recognise that Australian government policies will increasingly push the construction industry to reduce its energy consumption and carbon emissions, with incentives from the Emissions Reduction Fund and other climate change mitigation schemes.

In response to this growing urgency, Hub researchers have prioritised the exploration of various means of carbon capture and utilisation (CCU) – from mineral carbonation and bioconversion to chemical conversion and direct utilisation. They aim to optimally integrate the latest CCU developments into their work with construction materials.

Mineral carbonation – the most widely researched method of CCU in this field – involves reacting CO2 with basic minerals or metal ions found in wastewater, demolition waste, cement kiln dust, fly ash and paper mill waste. This forms highly stable, environmentally benign carbonates, which can be readily used as fillers or supplementary cementitious materials. It also makes possible a low-carbon alternative for the curing of concrete.

Bioconversion, on the other hand, relies on microorganisms or enzymes, such as urease and carbonic anhydrases, to convert waste into usable products or energy sources. This has great potential in the manufacture of self-healing construction materials.

Well established in the oil and chemical industries, chemical conversion has yet to penetrate the construction industry. CO2 can be chemically converted into polymeric materials, such as polycarbonate panels, but the requirement for high-purity CO2 makes the process expensive.

A number of industries utilise CO2 directly. For example, the food and drink industry commonly use CO2 as a carbonating agent, preservative and packaging gas. Direct utilisation may soon find even broader applications – perhaps in the production of foamed construction materials.

Carbon capture and utilisation could contribute up to 56% of the cement sector’s planned reduction of carbon emissions. Not to mention its impact across other sectors. By embracing CCU, the Hub hopes to lead the construction industry on its way to carbon neutrality.

THE HUB’S JOURNEY FROM BRIGHT IDEA TO SHINING FUTURE

In late 2013, a few of us came together at Monash University and had a brainwave: Why not create a university-industry consortium for the advancement of construction materials through nanoscience? The idea stuck and a year later we submitted a proposal to the Australian Research Council (ARC). To our disappointment, the first application for funding did not fly. Undaunted, we devoted the next year to perfecting our proposal and this time it met with success.

The ARC announced approval of our Industrial Transformation Research Hub for Nanoscience-based Construction Material Manufacturing, more commonly known as the Nanocomm Hub, in mid-2016. Led out of Monash University, this multidisciplinary research hub soon evolved into a thriving network of 13 Australian and three overseas universities and 48 industry partners across Australia, New Zealand, China, Singapore and South Korea.

Collaborating with key national and international industry partners, we’ve responded to an increasing demand for a step change in the construction industry. Our industry partners recognise the need to modernise their business and develop innovative products, systems, processes and technologies. Adopting a transformative agenda has moved each company towards a vibrant business model.

The Hub has also gathered a world-class team of researchers from Monash University, University of Melbourne, RMIT University, Swinburne University of Technology, Deakin University, University of New South Wales, University of Technology Sydney, Western Sydney University, University of Wollongong, University of Queensland, University of South Australia, University of Western Australia and Australian Catholic University.

Together our industry and university partners explore, turning over new ideas and sparking technological innovation, throughout the construction industry. They share the overarching goal of creating lighter, more resilient materials to help build a more efficient, sustainable and liveable Australia.
Since its inception, the Hub has delivered a total of around 60 projects across five key sectors of the Australian economy: construction, transport, aquaculture, mining and manufacturing. The Hub’s research has led to more than 550 publications, commercialisation of 8 patents, 20 construction products and 17 sets of new industry guidelines/Australian standards. We’ve also trained over 60 PhD students – the next generation of academic and industry leaders.

In recent times, we’ve all had to make adjustments to our way of working. Universities have been urged by new federal Education Minister Alan Tudge to put greater focus on research translation and commercialisation. Now in our fifth year, we find ourselves in a strong position to embrace this government agenda.

As agreed by the Scientific and Industry Advisory Committees, our marketing activities will promote the impact of our research on end users. For instance, we’ll more often feature a project in the Hub newsletter. Check out the current issue’s ‘Intelligent structural health monitoring: an ounce of prevention worth a pound of cure’ – the first story to highlight our achievements in asset management for infrastructure.

Wenhui Duan
Director, ARC Nanocomm Hub
1.2 About the Nanocomm Hub

Australia’s continued prosperity depends on the construction materials industry, which manufactures and distributes cement, concrete, aggregates such as gravel and crushed stone, polymer composites used, for example, in fibre-reinforced polymer composites, and chemicals. All in all, this massive industry contributes nearly $12 billion to our gross domestic product (GDP). Further, it employs 18,000 Australians directly and 85,000 indirectly.

To drive economic growth and enhance the quality of life of Australians, we must create sustainable and resilient infrastructure – infrastructure that requires less maintenance and can resist extreme weather conditions and even terrorist attacks. That’s why the Federal Government has committed a record $50 billion to infrastructure from 2014-15 to 2019-20. Combined with state, territory and private sector investment, this initiative will likely have spurred over $125 billion of infrastructure spending nationwide by 2020.

To realise investors’ ambitions, we need a steady supply of innovative construction materials from local sources. But can our construction materials industry meet Australia’s substantial infrastructure needs? Although historically a major source of jobs and revenue, the industry has recently been challenged by declining employment, rising energy costs and competition from low-cost Asian imports. Responding to these challenges, the Hub has undertaken the development of high-value products and specialised manufacturing operations that will keep the industry ahead of the game.

1.3 Vision

As a world-class research centre, the Nanocomm Hub seeks to develop materials and technologies that will elevate the global competitiveness and profitability of the Australian construction sector.

1.4 Mission

By promoting collaboration among Australia’s best minds in academia and industry, we aim to advance the construction materials and technologies through nanoscience and nanoengineering, while providing hands-on experience to our future workforce.
2.1 Graphene moves construction industry towards carbon neutrality

2.1.1 BACKGROUND

Global cement production has expanded thirtyfold since 1950, and has nearly quadrupled since 1990. As the world’s single biggest industrial cause of carbon pollution, it now finds itself under intense scrutiny. To reach the Paris Agreement’s net-zero target by 2050, the cement industry must cut its 2.2 gigatonnes of annual carbon emissions by about one third. And the world is watching.

2.1.2 AIMS AND GOALS

To help the cement industry achieve carbon neutrality, numerous strategies have been proposed: (1) saving energy in cement production, (2) greater use of alternative fuels, (3) embracing novel manufacturing technologies, (4) blending cement with industrial by-products and (5) developing clinker-free cements and cements with less clinker. But technological difficulties, material shortages and high costs have impeded the pursuit of these options.

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2.1.3 INNOVATIONS AND KEY FINDINGS

Seeking a better solution, Hub researchers have turned their attention to graphene-based nanosheets (GNS), such as graphene, graphene oxide, reduced graphene oxide and graphene nanoplatelets, as a way to reinforce cementitious materials. The addition of just a small amount of GNS can dramatically increase the compressive/tensile strength and durability of cement. And its excellent electrical and thermal conductivity facilitates self-sensing and thermal efficiency.

This innovative technology can directly and indirectly benefit the environment through creation of energy-efficient materials, conversion of plastic waste into graphene, greater capacity for use of industrial by-products in concrete and, crucially, less consumption of Portland cement. By enabling more efficient and economical concrete production and maintenance, GNS reinforcement has the potential to vastly reduce carbon emissions.

For full details, please refer to “Graphene opens pathways to a carbon-neutral cement industry”.

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2.1.4 TEAMS

Leading CI: Prof Wenhui Duan
2.2 Swapping sludge for sand makes greener and durable concrete

2.2.1 BACKGROUND

The world’s exploding population, along with economic development and changing consumption patterns, have dramatically increased demand for domestic and industrial water. Mainland Australia alone now has about 400 drinking water treatment plants, with a single site annually generating up to 2,000 tonnes (dry weight) of drinking water treatment sludge (DWTS)* – the waste from purification processes. Water utilities tend to dispose of DWTS in landfills – without innocuous treatment – at great expense and to the detriment of the environment.

* DWTS stockpiles at a landfill, DWTS concrete blocks (with 30% cement replacement), photo by Yue Liu
2.2.2 AIMS AND GOALS

To meet this challenge, for the first time ever in Australia, Hub Chief Investigator Professor Yan Zhuge has created durable concrete blocks with DWTS as a partial replacement for sand or cement. Using DWTS instead of fine aggregate, such as sand, or cement in concrete products offers an economical and environmentally friendly way to dispose of DWTS, and preserves our diminishing natural resources.

2.2.3 INNOVATIONS AND KEY FINDINGS

In collaboration with the South Australian Water Corporation (SA Water), Professor Zhuge and her team at the University of South Australia discovered that replacing up to 20% of sand (by weight) with DWTS improves the durability of concrete, most notably by preventing alkali-silica reaction. They employed an advanced CO2 curing technology to boost the concrete’s mechanical performance and its resistance to sulphate attack, with potential to act as a substantial carbon sink.

Both water utilities and cement manufacturers will benefit economically from the commercialisation of DWTS as a partial replacement for fine aggregate or cement in concrete products. Like fly ash and slag, DWTS can be used as a supplementary cementitious material. Companies that adopt this technology will advance the circular economy and move towards carbon neutrality.

This innovative research shows that DWTS pavers and mortar can meet or exceed the performance requirements for products made with conventional concrete. With as much as 30% cement replacement, DWTS blocks have a compressive strength of 13 MPa – higher than the minimum of 12.5 MPa required for load-bearing blocks (BS EN771, 2011).

SA Water now plans to use DWTS pavers in a public area at one of its water treatment plants. DWTS mortar also shows promise as a lining material to mitigate microbial corrosion (due to sulphuric acid attack) of concrete sewage pipes.


2.2.4 TEAMS

Leading CI: Prof Yan Zhuge
Team members: Mr Weiwei Duan, Dr Yue Liu.
Partner investigator: Dr Alex Keegan
2.3 Cement That’s Greener, Stronger and Water-Resistant

2.3.1 BACKGROUND

Buildings. Bridges. Roads. Dams. We live in a concrete world, and that concrete largely consists of Portland cement, whose manufacture pumps out up to eight percent of global carbon emissions. To counteract this, Professor Yixia (Sarah) Zhang, Nanocomm Hub Chief Investigator, and her team have dedicated themselves to creating an environmentally friendly alternative: a next-generation magnesium oxychloride cement (MOC).

MOC is a mix of magnesium oxide powder and a concentrated solution of magnesium chloride (industrial by-product) that quickly achieves great compressive strength. In contrast to Portland cement, MOC is greener because of the lower energy consumption and absorption of atmospheric carbon dioxide. Furthermore, MOC can work well with urban waste and keep good performance. However, due to its poor water resistance and resulting loss of strength, MOC has previously only been suitable for indoor use - for example, in floor tiles, decorative panels and thermal insulation boards.
2.3.2 AIMS AND GOALS

The researchers therefore set out to improve the water resistance of MOC by adding fly ash (a coal manufacturing by-product), silica fume (waste from the production of silicon metal or ferrosilicon alloys) and other additives. They developed a formula using these additives and found that together these components made the cement denser, significantly improving both its compressive and flexural strength under water attack.

As promising as these results may be, Professor Zhang has been expanding the research to develop more durable materials with enhanced performance for indoor application and potential outdoor application as non-structural components. The recently awarded ARC Discovery Project on developing hybrid fibre reinforced high performance MOC based fire resistance materials for application in claddings is one of such examples.

2.3.3 INNOVATIONS AND KEY FINDINGS

In fact, this modified MOC fully retained its strength after soaking in room temperature water for 28 days, at values much greater than those reported in literatures so far. Furthermore, with the addition of phosphoric acid and soluble phosphates, it retained up to 90% of its compressive and flexural strength in hot water (60°C) over the same period - still far beyond the norm.

2.3.4 TEAMS

Leading CI: Prof Sarah Zhang
PI: Dr Khin Soe
PhD researcher: Yingying Guo
2.4 Sustainable and economical fireproofing rises from the ashes

2.4.1 BACKGROUND

Conventional SFRMs use gypsum or Portland cement as a binder for passive fire protection. Although these materials can thermally insulate structures to delay or even prevent failure, they are susceptible to delamination and partial loss due to their poor bonding with steel. They also contribute significantly to greenhouse gas emissions and consume large amounts of natural and non-renewable resources.
2.4.2 AIMS AND GOALS

To protect steel and concrete structures against the intense heat of fire, Hub Chief Investigator Professor Zhong Tao has developed a sprayed fire-resistive material (SFRM) based on fly ash – an abundant waste product of coal-fired power stations. This valuable innovation will promote sustainable building construction and a circular economy.

2.4.3 INNOVATIONS AND KEY FINDINGS

In collaboration with Nu-Rock Technology, Professor Tao and his team at Western Sydney University’s Centre for Infrastructure Engineering have converted waste fly ash into a novel binder that shows outstanding fire resistance and greatly improved bond strength and durability with excellent sprayability.

This advancement not only reduces carbon emissions, but it is also far more cost-effective than other SFRMs on the market. The team has conducted extensive research to ensure that it offers the level of fire protection required by the Building Code of Australia.

Nu-Rock Technology plans to undertake commercialisation of this sustainable and value-added product in 2022, with a target to provide fire protection of 20 steel buildings by 2024. This will generate a multitude of jobs, and an estimated $6 million in revenue, boosting the construction industry and the Australian economy.

Professor Tao has also strived to perfect solar roof tiles. This work has attracted media attention: Solar tile with passive cooling and We can make roof tiles with built-in solar cells – now the challenge is to make them cheaper.

2.4.4 TEAMS

Leading CI: Prof Zhong Tao
PI: Mr Maroun Rahme and Mr Daniel Rahme
Researcher: Dr Zhu Pan, Dr Md Kamrul Hassan, Mr Qingtao (Edward) Huang.
3.1 Computational Uncertainty Structural Safety

3.1.1 BACKGROUND

Modern structural systems often serve under dynamic circumstances with continuous changing variabilities in loading environments, systematic properties and undesirable defects. During the long period of components’ service life, there exists a certain time that specific supplement or patch is unable to against some damage behaviors. This highlights the significance of failure prognosis before single or multiple operations, in order to prevent the potential damage evolutions. And it depends on a large extent of the capability of damage prediction against the up-to-date variability.

Mitsubishi Heavy Industries (MHI) delegation’s visit to Prof Wei Gao’s research group at UNSW, from right to left: MHI- Mr Tomohiro Ishida, Mr Akio Kitada, Mr Hiroshi Katsuura and UNSW- Prof Wei Gao, Dr Di Wu, Mr Qihan Wang, Dr Yuan Feng.
3.1.2 AIMS AND GOALS

To evaluate the real-time safety and reliability of fracturing engineering structures with uncertainties, Hub Chief Investigator Professor Wei Gao and his team have developed a powerful machine learning aided non-deterministic damage prediction framework for both 2D and 3D practical engineering applications. The outcome of this research contributes to the advancement in the knowledge of the broad classes of non-deterministic analysis and fracture problems with wide applications in engineering and science technologies.

3.1.3 INNOVATIONS AND KEY FINDINGS

It enriches the fundamental base of computational fracture mechanics, machine learning and structural safety as part of the important disciplines of fundamental and applied sciences with complementary skills. Original research has been conducted to develop innovative approaches.

A framework for the fracture safety analysis of engineering structures, considering polymorphic uncertainties in structural parameters and loadings as well as nonlinearities in material and geometric properties, are established. A powerful and novel unified machine learning technique has been incorporated into the phase field crack growth model, such that a continuous damage diagnosis-prognosis loop can be established to assess the latest working condition of the structure.


3.1.4 TEAM

Leading CI: Prof Wei Gao
Researcher: Dr Yuan Feng
3.2 Safe use of aggregates susceptible to ASR

3.2.1 BACKGROUND

Alkali-silica reaction (ASR) in concrete can cause concrete to expand and then crack. If the cracking arising from ASR is not contained, the concrete loses its functionality. This, in turn, requires repair, rehabilitation and possible decommission of the affected concrete structure. To avoid such issues, asset owners may limit the use of potentially reactive aggregates in concrete and specify additional mitigating measures in formulating the concrete. In service, they may also routinely apply surface treatments to prevent moisture ingress, inhibiting concrete expansion.
3.2.2 AIMS AND GOALS

Unfortunately, the application of such precautions significantly increase the cost of concrete. They also place a burden on the environment, as non-reactive aggregates are in short supply. That is why Dr Kirk Vessalas, Head of Discipline, Structural and Materials Engineering, School of Civil and Environmental Engineering at the University of Technology Sydney (UTS), has set out to develop novel strategies for the use of potentially reactive aggregates in concrete.

In partnership with Concrete New Zealand, Dr Vessalas has been working to advance applied research in concrete durability. He is leading a team of female researchers at UTS in exploring ways to use potentially reactive aggregates with minimal risk of deleterious ASR. Suppliers, contractors and asset owners in both New Zealand and Australia recognise the significance of this project.

The most common practice adopted in codes of practice worldwide to mitigate ASR involves conservatively imposing a maximum alkali limit of concrete. Yet findings to date point to ways potentially reactive aggregates can be safely used when the alkali exceeds the imposed limits. The main source of alkali in concrete comes from Portland cement. Other sources include aggregates, chemical admixtures, water and supplementary cementitious materials (SCMs).

3.2.3 INNOVATIONS AND KEY FINDINGS

Traditionally, SCMs such as fly ash and ground-granulated blast-furnace slag are used in concrete to prevent ASR, but they are becoming scarce in supply. Accordingly, the time has come to look at new solutions beyond SCMs and trial aggregate combinations with varying levels of alkali. For example, mixing a potentially reactive aggregate with a non-reactive aggregate or altering the alkali limit for aggregate rock types could present a sustainable option. Dr Vessalas and his team rely on physical expansion tests, petrographic examination, dissolution studies and elemental analysis as the screening methods for ASR to facilitate such an investigation.

The RILEM Recommendations for the Prevention of Damage by Alkali-Aggregate Reactions in New Concrete Structures have been helpful in assessing the reactivity potential of different rock types, aggregate combinations and alkali contents. Dr Vessalas maintains that the guidelines in this book will provide the foundation for a comprehensive set of new protocols to be developed and adopted in New Zealand, Australia and other parts of the world for the safe use of aggregates susceptible to ASR.

3.2.4 TEAM

CIs: Dr Kirk Vessalas (Lead), Dr Elsie Nsiah-Baafi, Dr Paul Thomas, Dr Marie Joshua Tapas, Prof. Vute Sirivivatnanon
PIs: Mr Rob Gaimster, Dr James Mackechnie, Ms Sue Freitag
3.3 Waterborne protective coatings

3.3.1 BACKGROUND

The emission of volatile organic compounds (VOC) has caused environmental pollution and brought negative effect on human health with the use of solvent-based coatings. In order to solve the VOC issue, many countries have successively established strict environmental regulations and this had promoted the progress of water-based coatings. Compared to solvent-based coatings, the development of waterborne coatings have not only low or no VOC emission, but also low risk of fire hazards and reduce users’ exposure to organic solvents.

Corrosion testing of nanostructured waterborne coating
3.3.2 AIMS AND GOALS

In order to design and develop waterborne coatings with desirable functions for industry applications, the following strategies were proposed: (i) identifying an appropriate waterborne acrylic base; (ii) introducing other components to the waterborne acrylic base to improve the performance and achieving functional waterborne coatings (corrosion/chemical/thermal/water resistances); and (iii) investigating the interfacial interactions between different components and the formation of nanostructures.

3.3.3 INNOVATIONS AND KEY FINDINGS

- An approach to developing waterborne coatings with desirable performance and functionalities has been demonstrated by incorporating different chemical components through copolymerization and the formation of micro/nanostructure composites of acrylic-based copolymers.
- Copolymerization and the formation of micro/nanostructure could achieve uniform distribution of different components in waterborne acrylic base in order to improve coating properties, performance and functionality, such as corrosion resistance, chemical resistance, water resistance and easy-cleaning performance.
- The nanostructure of the acrylic copolymer is ease of manipulation and this can be used to design highly organized nanostructure. Through designing more organized nanostructure, waterborne acrylic-based coating with multi functions could be developed for wide industry applications.

3.3.4 TEAM

Leading CI: Prof Mike Tan, Prof Qipeng Guo, Researcher: Dr Ming Zhou, Sha Ji, Guangwu Guan
4.1 Intelligent structural health monitoring: an ounce of prevention worth a pound of cure

4.1.1 BACKGROUND

Now under greater and greater demand, Australia’s ageing transport infrastructure requires a program of comprehensive monitoring, maintenance and renewal. This will ensure that critical structures such as bridges, jetties and ports can fulfill performance requirements today and in the decades ahead.

4.1.2 AIMS AND GOALS

With this in mind, Hub Chief Investigator Associate Professor Lihai Zhang has developed an advanced algorithm for use with unmanned aerial and surface vehicles to monitor structural health and assess life-cycle performance. Together these technologies will extend infrastructure service life, promoting productivity and sustainability of transport systems.

(a) Structural health monitoring of jetty using advanced non-destructive techniques in collaboration with Port of Hastings. (b) Intelligent structural health monitoring of jetty using drones in collaboration with Port of Melbourne. (c) & (d) Inspection of Port of Melbourne jetty using unmanned boat
4.1.3 INNOVATIONS AND KEY FINDINGS

Most Australian bridges have already been around for over half a century. Transport for NSW alone manages 5,287 bridges with a replacement value of $17.3 billion. Associate Professor Zhang’s protection & management team at the University of Melbourne have therefore set out to devise non-destructive testing techniques to determine optimal maintenance intervention cycles. Relying on drone and unmanned boat floating reference points, they can now detect structural flaws at nanometre scale. This proactive approach could extend the service life of bridges and jetties by up to 50%, saving the transport industry as much as $9 billion.

“Ageing bridges that face increasing demand from heavy traffic may fail to satisfy important structural requirements and societal need,” said Nigel Powers, National Infrastructure Strategist at the Australian Road Research Board (ARRB), “The modern non-destructive technologies developed by the research team from University of Melbourne are helping to monitor and maintain safer bridges across Melbourne and around the world.”

Automated inspection brings a multitude of benefits. A bridge currently in use can be assessed without disrupting traffic. Inspection can take place more often for timely preventative measures. In contrast with conventional visual assessment, drones with infrared thermography allow subsurface defect inspection. Further, large imaging data processing invites the implementation of artificial intelligence. And last but not least, easy access to difficult-to-reach places (e.g. under a jetty or high bridge) helps keep transport workers safe.

Andrew Ternes, Hydrographic Surveyor at Port of Melbourne, pointed out: “The implementation of drones, unmanned boats and underwater robots in structural health monitoring of port infrastructure could potentially lead to cost-effective routine inspection and improve safety for both workers and the public.”

Associate Professor Zhang’s research has led to the recommendation of industry guidelines: VicRoad’s Road Structures Inspection Manual and Ports Australia’s Wharf Structures Condition Assessment Manual. This tacitly acknowledges the potential of intelligent structural health monitoring to augment not only the movement of freight, but our nation’s economic growth.

ABC News interview August 2018 to discuss “How healthy is our transport infrastructure?” - above left

Course leader for continuing professional development and training in the industry – Structural health monitoring of civil engineering structures (Department of Transport and Main Roads, Queensland Government; 11–12 April 2018) - above right

4.1.4 TEAM

Leading CI: Prof Lihai Zhang

THE UNIVERSITY OF
MELBOURNE

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4.2 Closing the gap between the design and reality of sustainable buildings

4.2.1 BACKGROUND

Despite various strategies to conserve energy and reduce greenhouse gas emissions, most buildings do not perform as intended. Some consume as much as three times the predicted amount of energy. Based on an extensive literature review, countless interviews with experienced professionals and in-depth case studies of an educational building and an office building, Nanocomm Hub Chief Investigator Dr Morshed Alam of Swinburne University of Technology developed strategic frameworks to tackle BEPG in design and construction, as well as in building operation. In doing so, he collaborated with Aurecon, the Queensland Department of Housing and Public Works and the Western Australia Department of Finance.
4.2.2 AIMS AND GOALS

Dr Morshed points to multiple factors across the building lifecycle that drive BEPG: inaccurate assumptions, poor design and uncertainties in simulation tools during the design stage; value engineering, poor construction quality and materials, time pressure and incomplete commissioning during construction; and inefficiently controlled services, inadequate knowledge and skills of facility managers, degradation of system efficiency, complex occupant behaviours and extreme outdoor conditions during building operation. Insufficient accountability and poor communication among stakeholders also contribute to BEPG.

4.2.3 INNOVATIONS AND KEY FINDINGS

His framework for the design and construction stage features strategies for better regulation (to promote industry accountability), strategies for the project team (to ensure effective communication among stakeholders and minimise the inaccuracy of energy models) and suggestions for training (to educate the industry and upskill designers, contractors, sub-contractors, tradespeople and others involved in building projects).

His framework for the operational stage offers measures and strategies to prevent or overcome the gap in the post-occupancy period. These include ongoing monitoring, tracking and fine-tuning of building systems, collaborating with occupants, training and support of facility managers, documentation, and energy efficiency tax incentives. Additionally, Dr Morshed has proposed a novel “Total Facility Management” contract that would give the building owner assurance of its efficient operation for a fixed fee.

This research has heightened awareness of the critical role of operational energy performance, with an aim to shift attitudes in the construction energy. Relying on technologies and regulation is not enough – all the effort of creating energy-efficient buildings goes to waste if they’re not operated and maintained correctly.

As a signatory to the Paris Agreement on climate change, Australia has committed to reducing its total greenhouse gas emissions to 26-28% below 2005 levels by 2030. Our building sector produces about 23% of overall emissions. Improving the energy efficiency of building stock could potentially reduce these emissions by 55% over the next 30 years, using technologies that exist today. Dr Morshed’s work will no doubt contribute significantly towards achieving these goals.

4.2.4 TEAM

Leading CI: Dr Morshed Alam
5.1 Bridge Deterioration and Prioritization

5.1.1 BACKGROUND

Melbourne metropolitan network has 800 bridges on arterial roads. Across Victoria, there are approximately 3500 bridges and 2500 culverts on arterial roads managed by State Government. In addition, each bridge has an average 10 components, resulting in 40,000 bridge components. As bridge structures are subjected to constant deterioration and random damage events from man-made and natural hazards, a risk-cost-effective asset management strategy remains challenging.
5.1.2 AIMS AND GOALS

In collaboration with Department of Transport (formerly VicRoads), Nanocomm Hub RMIT research team lead by Prof Sujeeva Setenge and Dr Huu Tran aims to model the deterioration and predict future condition of bridge components by using level 2 visual inspection data available in large quantity as compared to level 3 detailed investigation.

5.1.3 INNOVATIONS AND KEY FINDINGS

The stochastic Markov chain theory has been found to be the best suitable deterioration model for capturing the stochastic nature of deterioration of bridge and culvert components and discrete their condition rating data.

The outcomes of this project are the calibrated and validated Markov deterioration models for all components of bridge and culverts by material types, component types and location types.

The benefits of this project include the evidence-based budget forecasting of periodic maintenance using developed deterioration models and the identification of data and modelling gaps for further improvement of asset management of bridge and culvert structures.

“The finding outcomes have been developed an internal guideline and also, recommended to be included in the existing Road Structures Inspection Manual.” – comments from the partner investigator Dr Yew Chin Koay.

5.1.4 TEAM

CIs: Prof Sujeeva Setenge (lead), Dr Huu Tran
PIs: Dr Yew-Chin Koay, Dr Iftekharul Alam
5.2 Novel Hybrid FRP-Concrete-Steel Double Skin Tubular Truss Bridge Systems

5.2.1 BACKGROUND

This project investigated the behaviour of the Novel Double Skin Tubular Arch (DSTA) Bridge system invented by Rocket C in partnership with the University of Queensland. Theoretical and experimental research carried out under this project developed an accurate methodology to carry out the design of DSTA bridges, developed cost efficient manufacturing methodology, and demonstrated the excellent load carrying capacity.
5.2.2 INNOVATIONS AND KEY FINDINGS

DSTA bridge showed significantly higher load carrying capacity than equivalent weight reinforced concrete or steel bridge girders.

DSTA bridges were shown to reduce over 35% CO2 emissions compared to an equivalent capacity reinforced concrete bridge girder.

DSTA bridge won the prestigious BERD-FEUP Prize for World Innovation in Bridge Engineering.

Data from this project allow the design of DSTA bridge systems to be approved and certified by structural engineers, thus allowing wide use of the DSTA bridge concept.

This project led the direction into many new research, including optimized truss systems consisting of double skin tubular compression members, many new arch bridge systems consisting of double skin tubular members.

“It is three times as strong as conventional bridges, yet only a third the weight. Because it is light, the bridge can be pre-fabricated and transported to site where it can be put up in about 72 hours. This means projects that previously caused up to six months of disruption can now be completed in just three days.” – Dr Dilum Fernando.

The award-winning innovation – a double skin tubular arch bridge – has the potential to reduce major bridgeworks projects from months or even years to just three days saving time, money and inconvenience.

5.2.3 TEAM

Leading CI: Dr Dilum Fernando and Prof Sritawat Kitipornchai
6.1 Building the last line of defence against dangerous coal bursts

6.1.1 BACKGROUND

Two men died 500 metres underground in a New South Wales coal mine in 2014. They’d been operating a continuous mining machine when hundreds of tonnes of coal collapsed on them. This tragedy sparked an investigation that determined that existing protective systems were woefully inadequate, prompting tighter safety regulations.

6.1.2 AIMS AND GOALS

To meet the new industry standards, Hub Chief Investigators Associate Professor Ting Ren and Professor Alex Remennikov set out to innovate a protective system for continuous miners in underground coal mines. The two researchers, both from the University of Wollongong, have collaborated on this project with industry partner Peter Holt of Ironclad Mining Machinery.

“We wanted to design a new protective system that could be installed on continuous miners as the last line of defence after all other mitigating measures fail,” explained Associate Professor Ren. “Our aim was to protect people working on these machines against the hazard of coal bursts while building roadways in highly stressed and gassy coal seams.”
6.1.3 INNOVATIONS AND KEY FINDINGS

The team first explored the dynamic loading produced by coal outbursts – in other words, the impact of ejected coal fragments. They devised analytical formulas to predict the dynamic load and kinetic energy of flying coal and the resulting impact on continuous miners. This included a worst-case scenario: a coal block with a diameter of 0.8 metres ejected at a velocity of 20m/sec.

They then put their minds to an actual protective system that could be readily assembled underground. They built a prototype with a number of energy-absorbing honeycomb panels made of very thin steel, with a height of 1.5 metres to protect the full body of a miner. A cover plate is robotically welded to the honeycomb core, with each panel requiring several hundred welds.

Through impact testing, the team assessed the energy-absorbing capacity of the panels. They found that, even with 600 kg of coal dropped from a 5-metre height at a velocity of 9 m/s, the panels could absorb a significant amount of energy without disintegration. Further, they were excited to discover that their numerical modelling closely corresponded to their experimental results.

“We then used computer prototyping to design frames to hold the protective panels,” said Professor Remennikov. “We wanted to ensure the frames could absorb sufficient energy and not fail under the maximum impact of flying rocks. We looked at different designs until we arrived at one that successfully resisted maximal impact loads without failure of its elements.”

The three protective panels slide into the frame for easy installation. Again, maximal testing of 600 kg from 5 metres showed a highly reliable performance of the system. Although plastic deformation of the panels occurred, they still had elasticity to rebound and hold the load. The team tested the panels at both the top and central parts of the frame to make sure that the system would perform satisfactorily in all impact scenarios under maximum load. Additionally, numerical modelling proved consistent with experimental results.

“With such promising results, we can now proceed to the implementation stage,” remarked Associate Professor Ren and Professor Remennikov. “Our continuous miner protective system can resist the impact of large fragments of coal flying at high velocity. We plan to present this system to coal industry operators and coal industry equipment designers at the COAL2021 conference. There we hope to generate significant interest in its further development. This will undoubtedly bring about important outcomes for the coal industry and worker safety.”

6.1.4 TEAM

CIs: Prof Ting Ren, Prof Alex Remennikov
PI: Peter Holt
6.2 Apple Robot steps up for smart farming

6.2.1 BACKGROUND
Anyone who has spent a working holiday picking apples knows how physically demanding it is. That's why farmers traditionally have hired young and fit backpackers and other robust seasonal workers at harvest time. But access to this vital labour source can be limited, both here and overseas, with a push for apple-picking robots to fill the gap.

6.2.2 AIMS AND GOALS
Dr Chao Chen and his team at Monash University’s Laboratory of Motion Generation and Analysis, in collaboration with Thor Tech, have taken action. They have developed a game-changing Apple Robot. Now in its third generation, this innovation has evolved to progress autonomous harvesting. No mean feat.

“Our hands are extremely dexterous, and capable of intricate and very fine control, which makes picking an apple off a tree a trivial task for us,” explains Dr Chen. “However, replicating this motion in a robotic system is quite challenging, especially given the speed, reliability and quality of human performance.”

To guide the Apple Robot on its path to grasp and detach fruit, the team has employed an advanced depth camera coupled with neural-network algorithms derived from deep learning. This sophisticated vision feedback system allows the approach trajectory to be based on a full three-dimensional virtual model of an orchard.

6.2.3 INNOVATIONS AND KEY FINDINGS
The Apple Robot’s pneumatically-powered grippers feature soft, compliant fingers inspired by the Fin Ray effect. The fingers remain closed on approach to protect tree branches, and they conform to an apple’s shape to minimise damage to the fruit itself. Alternative picking patterns and intelligent grasp sensing have also enhanced task reliability. A remote-controlled mobile base will be added shortly.
Not only has the team rigorously tested the Generation 3 Apple Robot in the lab, they have put it to work in a complex orchard environment – a field test that successfully demonstrated its autonomous harvesting capability. Their effort culminated in a showcase of the Apple Robot at the 2019 AI Expo in Suzhou.

But there’s always room for improvement. And plans for the next generation are now underway.

“Generation 4 will feature a six-degrees-of-freedom articulated arm, reducing the overall size of the robot while maintaining a highly dexterous workspace,” says Dr Chen. “Also, improved environment sensing and mapping will allow visualisation in three dimensions – a significant upgrade – so that the robot can better sense obstacles and occlusions around apples in an orchard.”

In pursuing these advances, Dr Chen never loses sight of the bigger picture:

“It has been predicted that our increasing global population and decreasing arable land will lead to an agricultural crisis. I believe that smart farming, powered by robotics and AI, can prevent such a crisis, and ensure a promising future for agriculture. That belief inspires me to keep on advancing technology in this field.”
DECRA fellow Sherry Zhang views research from a wide angle

Trained in civil engineering and physics during her doctoral years, Dr Qianhui "Sherry" Zhang brings multidisciplinary skills and broad research interests to the Nanocomm Hub. As an Australian Research Council (ARC) Discovery Early Career Research Award (DECRA) fellow, she probes both the fundamental physics and engineering characteristics of novel 2D nanomaterials and their nanocomposites.

Dr Zhang primarily focuses on the synthesis and characterisation of these nanomaterials, incorporating them into engineering materials, such as timber, polymer and cement. She aims to augment the mechanical performance and multifunctionality of the nanocomposites. She also hopes to advance next-generation sensor development and energy conservation for the construction industry.

"This industry faces the growing challenges of a high carbon footprint and enormous energy consumption, creating an urgent need to develop stronger, more durable and more sustainable construction materials," says Dr Zhang. "Emerging 2D nanomaterials, such as graphene, show superior mechanical properties and multifunctionalities that make them well suited for integration into construction materials. In exploring these, we can reimagine the construction industry."

As part of the 2+2 Program, Dr Zhang completed her final two years of undergraduate civil engineering at Monash University after her first two at Central South University in China. (2+2 graduates earn two bachelor’s degrees, one from each university, making them global engineers.) She then completed her PhD in Civil Engineering at Monash before being awarded her DECRA fellowship there.

"Working in the Hub, I have the opportunity to connect and work closely with diverse research groups, as well as industry and government partners," explains Dr Zhang. "This greatly broadens my views and boosts my creativity. It also helps me to understand the needs of different stakeholders and orient my research directions."

Still early in her career, Dr Zhang has already published a number of articles in high-impact journals, such as Advanced Functional Materials, ACS Nano and Advanced Optical Materials. Watch this space.
PhD student Afifa Tamanna reworks our roads

As part of the Hub community, Afifa Tamanna has dedicated herself to developing a novel technique to characterise cutter oils (cutters) for optimal sprayed seal road construction. These solvents reduce the viscosity of bitumen binder, enhancing the adhesion between binder and aggregate.

Afifa has employed gene expression programming (GEP), an emerging area of artificial intelligence, to develop a non-destructive micro-CT characterisation technique. She has also relied on industrial experimentation. Combining these approaches has allowed her to generate practical and accurate diffusion models for sprayed seal solvents.

Now in the final year of her PhD in the Department of Civil Engineering at Monash University, Afifa has been working hand in hand with the Australian Road Research Board (ARRB) on an Austroads project. Their findings will inform the update of AS 3568, the standard used by Australian road agencies for solvent quality control.

“I hope my research will lead to more durable and sustainable sprayed seals for improved efficiency in road transport,” says Afifa. “This will help sustain Australian communities and economic prosperity.”

Before embarking on her doctorate, Afifa earned a Bachelor of Science in Civil Engineering from the highly regarded Bangladesh University of Engineering and Technology. Upon graduating, she lectured in the Department of Civil Engineering at Presidency University in Bangladesh.

Looking to the future, Afifa predicts, “Research on the characterisation and applicability of bio-oil in Australian sprayed seals could bring about another revolutionary step to address environmental issues.” In the meantime, she’ll keep up her good work.

Nanocomm Annual Report 2021
Hub acts as launch pad for early career researchers

Making the leap from graduate to professional presents enormous challenges. Dr Morshed Alam, Lecturer at Swinburne University of Technology, and Dr Marie Joshua “Josh” Tapas, Research Associate at University of Technology Sydney (UTS), reveal the many ways in which the Hub has helped their careers take off.

Morshed, a mechanical engineer, joined the Hub in 2017 as a research fellow. In his pursuit of ecologically sustainable development, the Hub encouraged him to work closely with industry partner Aurecon, as well as government departments. When Aurecon soon asked him to monitor the energy performance of a newly constructed building in Geelong, Victoria, Morshed jumped at the chance. This ideal placement fuelled his passion for finding innovative strategies to close the gap between the design and reality of sustainable buildings.

“I had the privilege of sitting in on the monthly stakeholder meetings at Aurecon, with all the main contractors, subcontractors and designers,” said Morshed. “Step by step, we analysed how the design was performing in real life – and where it had wrong to make decisions. I learned how dynamic an industry environment can be and the importance of resolving a problem within a given timeframe. This experience got me out of my academic mindset and gave me an understanding of how industry actually works.”

After recently completing her PhD in Civil and Materials Engineering, Josh joined the UTS Boral Centre for Sustainable Building at the UTS Tech Lab, where she now develops ultra-sustainable concrete. As a doctoral exchange researcher, she had spent several months learning best practices in cement chemistry at the Laboratory of Construction Materials at the École Polytechnique Fédérale de Lausanne in Switzerland. Josh also became involved with the Hub in 2017 and attributes much of her career success to its extremely supportive outreach.

“I had the privilege of sitting in on the monthly stakeholder meetings at Aurecon, with all the main contractors, subcontractors and designers,” said Morshed. “Step by step, we analysed how the design was performing in real life – and where it had wrong to make decisions. I learned how dynamic an industry environment can be and the importance of resolving a problem within a given timeframe. This experience got me out of my academic mindset and gave me an understanding of how industry actually works.”

“I suddenly moved from research fellow to chief investigator. This meant that I needed to make all the budget decisions related to Australian Research Council and industry funds, as well as serve as principal supervisor to PhD students,” explained Morshed. “As a new academic, this was at first a bit daunting, but I somehow managed and believe having done so will help me in future. As a CI, I have now secured my first funding from industry – to develop zero-energy residential building as a standard for Australia in 2022.”

The Hub makes a concerted effort to showcase the work of its students. Josh maintains that such exposure at various events facilitated networking which, in turn, lay the groundwork not only for new collaborations, but future employment. Based on her own experience, she offers this advice:

“If you’re going into industry, papers really don’t count when it comes to hiring. If you’re in civil engineering, for example, find the best-known professor in that field and impress them. Whatever that person says about you matters. With their recommendation, the likelihood of you getting a job is very high.”

Amongst the Hub’s very first graduates, Morshed and Josh hope to stay connected, with plans to return to the Hub as guest lecturers. By sharing their workforce experience with others just starting out, they will no doubt continue to be a source of great inspiration.
Mastering the wind to secure our future

Over the years, Junwei Lyu has become fascinated by wind and how it interacts with our built environment. His growing curiosity has now led him to CPP Wind Engineering & Air Quality Consultants in Sydney. He will soon join the company as a computational fluid dynamics engineer, most likely working in the areas of pedestrian wind comfort, pollutant dispersion and thermal comfort.

Driven by his conviction that global challenges such as extreme weather events demand engineering solutions, Junwei undertook a PhD in Civil Engineering (Structural Engineering), which he’ll soon complete, at the University of Queensland. There he was invited to take part in the prestigious Global Change Scholars Program, an initiative designed to produce research leaders.

Throughout his doctoral studies, the Nanocomm Hub has given Junwei an opportunity to exchange ideas and collaborate with academic and industry experts across many disciplines. And he found inspiration for his own research in the Hub’s “floating forest” – a mega breakwater/windbreak with rows of hollow plastic tubes along its tilted deck (mimicking a mangrove forest) to protect shorelines and structures against severe storms.

Supported by the Hub’s vast resources and an ARC Discovery Project, Junwei has carried out a comprehensive review of the flow mechanisms of conventional windbreaks. He has also investigated, both numerically and experimentally, how various geometries influence the wind speed behind the floating forest. Based on his findings, Junwei has devised empirical models to predict the leeward wind speed reduction of windbreaks. In doing so, he has combined traditional fluid mechanics theories with machine learning methods.

Previously, Junwei earned a Bachelor of Engineering in Civil Engineering (Structural Engineering) from the South China University of Technology. He also studied Structural Engineering and Building Technology in a Master of Science program at the Chalmers University of Technology in Sweden.

Looking ahead, Junwei projects optimism. “Given the abundant wind resources in Australia and around the world, harvesting wind energy both onshore and offshore will gain traction for a sustainable future,” he predicts. “Also, with the development of AI and our growing computing power, we’ll be able to respond to wind hazards far more confidently.”
Elise Nsiah-Baafi is a final year doctoral student at the School of Civil & Environmental Engineering, University of Technology Sydney (UTS). Her research interest lies majorly in Materials Science and Engineering- with expertise in materials development and characterization techniques. Elsie holds a BSc. in Materials Engineering from the Kwame Nkrumah University of Science and Technology in Ghana, and a master’s degree in Metallurgy from Tshwane University of Technology in South Africa. Her current PhD at UTS focuses on developing protocols for minimizing deleterious alkali-silica reaction (ASR) in concrete with the use of potentially reactive aggregates. Her work investigates alternative ASR mitigation methods to improve the durability of concrete. Elsie is working as part of the UTS construction materials researchers with Dr Kirk Vessalas, Dr Paul Thomas and Prof Vute Sirivivatnanon. Her PhD research is in collaboration with ConcreteNZ and provides an update to New Zealand’s best practise for ASR mitigation.

In late 2019, Dr Saeed Miramini was promoted to lecturer at the department of Infrastructure Engineering of the University of Melbourne (UoM). Prior to that he was a research fellow and teaching specialist at UoM. Dr Miramini serves as the Nanocomm Hub node manager at UoM and currently coordinating the upcoming Hub conference, 7th International Symposium on Nanotechnology in Construction (NICOM7).

Dr Miramini’s research focuses on Infrastructure Asset Management using Engineering Reliability and Non-Destructive Evaluation. He also applies the Theory of Porous Media from civil engineering to study the mechanobiology of bone and cartilage tissues. This innovative approach helps address global challenges associated with osteoporosis and osteoarthritis conditions. By conducting research in biomedical engineering, he also learns from nature and biology to propose innovative solutions to civil engineering problems, such as the development of self-healing concretes.
Dedicated to sustainable construction, PhD student Yue Liu has pursued environmentally friendly construction materials at the University of South Australia (UniSA). Notably, he has developed novel green concrete blocks by using drinking water treatment sludge (the waste from purification processes) as a partial replacement for sand or cement. Yue has been involved with two Australian Research Council projects, under the supervision of Professor Yan Zhuge. His research will culminate in the mass production of these durable concrete blocks, which will be exhibited at the South Australian Water Corporation. This achievement has inspired Yue to further his work on green construction materials.

As part of the Nanocomm Hub, Yue has benefitted from its vast resources and facilities. Thanks to its strong sense of community, he has had the opportunity to learn from top researchers and industry experts. Yue attributes much of his success to the help he has received from the Hub throughout his doctoral studies.

Having recently submitted his PhD thesis, Yue has now taken on the role of research assistant at the UniSA. Previously, Yue earned a Bachelor of Mechanical Engineering from China’s Northeastern University and a Master of Engineering (Mechanical Engineering) from the University of Adelaide.

Yue views the future with optimism. “Disposing of our abundant waste in the development of green construction materials will not only move Australia towards a circular economy, but also significantly reduce emissions,” he says. “And early-age carbonation curing technology holds great promise for cement-based materials with improved performance and a lighter carbon footprint.”
Hub PhD student braves the storm and heads out to sea

A lifelong fascination with deep-sea exploration has put Mengmeng Han on an exciting career path. This month she joins the Brisbane office of BMT Commercial Australia as an environmental/water modelling engineer. BMT is a leading international design, engineering, science and risk management consultancy.

During her past three years as a PhD student at the University of Queensland, Mengmeng has collaborated with Nanocomm Hub researchers from various backgrounds, gaining knowledge and expertise across a wide range of disciplines. This experience has informed her research on the ‘floating forest’ – a mega breakwater and windbreak to create a calm coastal zone for protection of fragile shorelines and offshore structures against severe storms.

An ARC Discovery Project grant has supported Mengmeng’s doctoral project from initial feasibility and detailed mechanism studies through analytical solutions, numerical modelling and experimental testing. This step-by-step process gave Mengmeng a comprehensive understanding of the physics of the floating forest, enabling her to develop a novel semi-analytical approach for robust modelling to optimise its breakwater performance.

Previously, Mengmeng earned a Master of Science in Offshore Technology from the National University of Singapore and a Bachelor of Engineering in Naval Architecture from Shanghai Jiaotong University. She also spent three years working on multiple consulting and R&D projects in the offshore oil and gas industry.

Mengmeng speculates on the next wave in her field: “I think we’ll see Australia fulfilling its carbon emission commitment by expanding the production of offshore renewable energy. With the initiation of the first offshore wind turbine project, and the gearing up of the Blue Economy CRC, we’ll head deeper offshore where many opportunities await.”
Anna Paradowska has achieved so much in so little time

Passionate about building bridges between academia and industry, Hub Industry Advisory Committee member Professor Anna Paradowska has dedicated her career to promoting long-term collaborations and partnerships with universities, other research organisations and businesses, in Australia and overseas.

Along the way, she has created an impressive track record of securing funding to access large-scale facilities around the world. In the short decade or so since receiving her PhD, she has helped win international and local industry focus grants (including Australian Research Council grants) totalling over $20 million.

Late last year Anna joined the University of Sydney as a Conjoint Professor of Practice (Advanced Structural Materials) in the School of Civil Engineering. She has also held the position of Industry Engagement Manager at ANSTO’s Australian Centre for Neutron Scattering since 2014.

Additionally, Anna has extensive experience with neutron strain scanners, having worked with both ENGIN-X at the Rutherford Appleton Laboratory’s ISIS Pulsed Neutron and Muon Source in the UK and Kowari at ANSTO.

She has published a book, two book chapters and over 180 papers in scientific journals and conference proceedings, many of which have won national or international awards.

“I’m excited that the advanced manufacturing, recycling, transport and structural engineering industries worldwide are exploring novel characterisation techniques,” says Anna. “Large-scale infrastructure, such as synchrotron and neutron scattering facilities, has become increasingly prevalent as a tool for academia and industry. I have no doubt this will make a significant impact on the development of novel materials and technologies in the near future.”

Strongly committed to advancing science, Anna trains and mentors the next generation of scientists and engineers in the use of large-scale scientific infrastructure. She also participates in various STEM programs and enthusiastically supports and mentors women in science and engineering.
GOVERNANCE

HUB DIRECTOR

MANAGEMENT TEAM
DIRECTOR, DEPUTY
DIRECTORS, ADMIN

ADVISORY COMMITTEE

STEERING COMMITTEE
DIRECTOR, DEPUTY DIRECTORS
AND GROUP FACILITATORS

RESEARCH TEAMS

RT1  RT2  RT3  ...  RT37

CIs  CIs  CIs  CIs  CI GROUP

PIs  PIs  PIs  PIs  PI GROUP

RFs  RFs  RFs  RFs  RF GROUP

HDRs  HDRs  HDRs  HDRs  HDR GROUP
8.1 MANAGEMENT TEAM

HUB DIRECTOR
PROF WENHUI DUAN

DEPUTY DIRECTOR (OPERATIONS)
DR KWESI SAGOÉ-CRENTSIL

DEPUTY DIRECTOR (SYDNEY)
PROF VUTE SIRIVIVATNANON

DEPUTY DIRECTOR (BRISBANE)
PROF SRITAWAT KITIPORNCHAI

DEPUTY DIRECTOR (MELBOURNE)
PROF SUJEEVA SETUNGE

PROJECT MANAGER
DR BILLY ZHENYUE CHANG
8.2 ADVISORY COMMITTEE

The Advisory Committee consists of the Hub Director, Hub Deputy Directors, and other academic and industry experts in the specific fields related to the research. The purpose of the Advisory Committee is to:

- Provide strategic advice, opinions and recommendations on the direction of Research Programs
- Provide industry input to the Hub Director
- Promote the objectives and outcomes relating to industry and engagement.

8.2.1 SCIENTIFIC ADVISORY COMMITTEE

PROF YIU-MING MAI
(Chair)
University of Sydney

PROF DAVID NETHERCOT
Imperial College of London

PROF JOSE TORERO
University of Maryland

MR RICHARD KELL
Cardno

PROF SER TONG QUEK
The National University of Singapore

PROF ROSE AMAL
The University of New South Wales

PROF MARK BRADFORD
The University of New South Wales

8.2.2 INDUSTRY ADVISORY COMMITTEE

PROF WENHUI DUAN
(Chair)
Monash University

DR PHILLIP ARENA
Fortis

DR ANNA PARADOWSKA
Ansto

DR RICHARD YEO
ARRB
8.3 STEERING COMMITTEE

The Steering Committee has four sub groups, i.e. Chief Investigator (CI) group, Partner Investigator (PI) group, Research Fellow (RF) group and HDR student group. Each group has one facilitator to promote the collaboration amongst hub members from different participant organisations and to provide advice to the Management Team on any concern/opportunities from CI, PI, RF and HDR.

PROF WENHUI DUAN  
Monash University

PROF SUJEEVA SETUNGE  
RMIT University

PROF VUTE SIRIVIVATNANON  
University of Technology Sydney

PROF SRITAWAT KITIPORNCHAI  
The University of Queensland

DR KWESI SAGOECRENTSIL  
Monash University

DR SHERRY QIANHUI ZHANG  
Monash University

ZAHRA NOURI EMAMZADEH  
Western Sydney University

FELIPE BASQUIROTO DE SOUZA  
Monash University

PROF BIJAN SAMALI  
Western Sydney University

DR CHAMILA GUNASEKARA  
RMIT University
HUB MEMBERS

8.4 CHIEF INVESTIGATORS

PROF WILLIAM YOUNG
Monash University

PROF JIAN ZHAO
Monash University

PROF WENHUI DUAN
Monash University

DR QIANBING ZHANG
Monash University

A/PROF AMIN HEIDARPOUR
Monash University

A/PROF MOHAN YELLISHETTY
Monash University

DR COLIN CAPRANI
Monash University

DR CHAO CHEN
Monash University

MR PETER MUTTON
Monash University

A/PROF RUIPING ZOU
Monash University

A/PROF WENYI YAN
Monash University

A/PROF VICTOR CHANG
Monash University

DR HUI HUANG
Monash University
8.6 RESEARCH FELLOWS

DR HUU TRAN  
RMIT University

DR SHAO LIU  
Monash University

DR KAMYAR KILDASHTI  
Western Sydney University

DR VAN THUAN NGUYEN  
The University of Queensland

DR SHERRY QIANHUI ZHANG  
Monash University

DR BOB ABTAHI  
Western Sydney University

DR YANG YU  
University of Technology Sydney

DR WENCHAO GAO  
Monash University
8.8 HDR STUDENTS

ERFAN AMIRI
RMIT University

JASPREET SINGH POONI
RMIT University

MUHAMMED KHDOR
RMIT University

YUBING OUYANG
Monash University

HAO SUI
Monash University

JIALU ZHENG
Monash University

VAN MANH PHUNG
Swinburne University of Technology

XIAOXIAO XU
Swinburne University of Technology

ATILA SARIKAYA
University of Technology Sydney

BABAR NASIM KHAN RAJA
The University of Melbourne

ZUNARIRA NASEEM
Monash University

BINBIN QIAN
Monash University

JUNWEI LYU
The University of Queensland

REZA BANI ARDALAN
Western Sydney University

ZAHRA NOURI
Western Sydney University

SHA JI
Deakin University
9.1 Key Performance Indicators

The Australian Research Council Industrial Transformation Research Hubs scheme has developed a key performance indicator (KPI) system to stimulate the translation of technological innovations from academia to industry. The system relies on 27 KPIs across six categories:

- research training and education
- research links and networks
- outputs
- outcomes
- end-user links
- benefits.

These occur in three phases: talent, excellence and impact (see diagram to right). Research training and education, research links and networks, and outputs combine to bolster excellence in university research, whereas outcomes, end-user links and benefits support the commercialisation of innovations by industry. By catering to the needs of both universities and industry, the KPI system maintains a balanced and mutually beneficial relationship between them.
2021 Key Performance Indicators

NETWORKING
- KPI: 100%
- Overseas visits: 0%*
- Nat and int'l visitors: 0%*
- Workshops held: 150%

OUTPUTS
- KPI: 100%
- Invited talks: 600%
- Research outputs: 269%
- Industry reports: 100%
- Commentaries: 183%

END-USER LINKS
- KPI: 100%
- End user briefings: 150%
- Industry visitors: 20%*
- Public talks: 17%*

TRAINING AND EDUCATION
- KPI: 100%
- HDR in PO: 150%
- PO mentors: 116%
- Core research HDR: 129%
- PO courses attended: 175%
- Mentoring programs: 130%
- New staff hired by PO: 100%

OUTCOMES
- KPI: 100%
- New processes and products arising from research: 114%
- New staff hired by PO: 100%
- HDR courses attended: 110%

BENEFITS
- KPI: 100%
- ROI: 125%

*Nanocomm Annual Report 2021
*Due to travel restriction and limited public events in 2021 caused by COVID
9.2 Publications

The Hub records research outputs as a measure of our contribution to technological innovation. Research outputs include journal article publications, industry reports and publications, as well as invited talks, papers and keynote addresses. The hub published 32 journal articles, 10 conference papers and 1 book chapter in 2021.


10 Conference Publications:

- Young, W., Shackleton, M., Bahroloom, S. (2021). Exploring a social science to operate the road system. Australian Transport Research Forum, Brisbane, Australia.


1 Book chapter:

9.3 Industry reports and publications

1. Ratcheting Behaviour of Flash Butt Welds in PG4 and R400HT Rail Steels under Uniaxial and Biaxial Cyclic Loadings, 2021
2. Ratcheting Behaviour of Flash Butt Welds in PG4 Steel Rails under Uniaxial and Biaxial Cyclic Loadings, 2021
3. Maryvale Energy from Waste Project, 2021
4. Green pavers from red mud – converting contaminated soil to non-kiln fired eco-pavers, 2021
5. Degradation resistance of different cementitious materials to phosphoric acid attack at early stage, 2021
6. Degradation of alkali-activated slag and fly ash mortars under different aggressive acid conditions, 2021
7. 1st industry report on structural performance of enhanced PVC permanent formworks
8. 2nd industry report on structural performance of enhanced PVC permanent formworks

9.4 Invited talks/papers/keynote addresses

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<tr>
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<tbody>
<tr>
<td>Wesley Au</td>
<td>Monash Apple Retrieving System (MARS), AU, 2021</td>
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<tr>
<td>Yan Zhuge</td>
<td>Can seawater and sea-sand solve the problems with concrete production?, Hong Kong and online, Hong Kong, HK, 2021</td>
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<tr>
<td>Sha Ji</td>
<td>Design waterborne protective coatings based on the copolymerization and nanostructure formation of acrylic-based polymers, Melbourne, AU, 2021</td>
</tr>
<tr>
<td>Wei Gao</td>
<td>Machine learning underpinned structural safety assessment, Hangzhou, Hangzhou, CN, 2021</td>
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<tr>
<td>Paul Thomas</td>
<td>Investigation of alkali content thresholds for deleterious alkali-silica reaction in concrete, SEMINAR ROOM / Online, UTS TechLab, 32-34 LORD STREET, BOTANY, NSW 2019, Sydney, AU, 2021</td>
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<tr>
<td>Paul Thomas</td>
<td>The role of alkali-silica reaction in the susceptibility of concrete to delayed ettringite formation, SEMINAR ROOM / Online, UTS TechLab, 32-34 LORD STREET, BOTANY, NSW 2019, Sydney, AU, 2021</td>
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<tr>
<td>Paul Thomas</td>
<td>Why and How SCMs mitigate ASR, SEMINAR ROOM / Online, UTS TechLab, 32-34 LORD STREET, BOTANY, NSW 2019, Sydney, AU, 2021</td>
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<tr>
<td>Paul Thomas</td>
<td>Evaluation of factors affecting the validity and correlation of concrete prism tests, SEMINAR ROOM / Online, UTS TechLab, 32-34 LORD STREET, BOTANY, NSW 2019, Sydney, AU, 2021</td>
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<tr>
<td>Paul Thomas</td>
<td>Modelling long-term expansion of field concrete from the expansion of CPT, SEMINAR ROOM / Online, UTS TechLab, 32-34 LORD STREET, BOTANY, NSW 2019, Sydney, AU, 2021</td>
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<td>Paul Thomas</td>
<td>Novel Accelerated Test for Assessing the Potential Risk of Alkali-Silica Reaction in Concrete, SEMINAR ROOM / Online, UTS TechLab, 32-34 LORD STREET, BOTANY, NSW 2019, Sydney, AU, 2021</td>
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<tr>
<td>Paul Thomas</td>
<td>Intrinsic modelling of residual capacity of ASR affected structures, SEMINAR ROOM / Online, UTS TechLab, 32-34 LORD STREET, BOTANY, NSW 2019, Sydney, AU, 2021</td>
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<tr>
<td>Edward Huang</td>
<td>Development of fly ash-based SFRMs, AU, 2021</td>
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### 9.5 media

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<tr>
<th>TITLE</th>
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<tr>
<td>Life in MARS? The Monash robotic apple-picker.</td>
<td>Apple and Pear Australia Ltd</td>
<td>Online</td>
</tr>
<tr>
<td>Robotic arm harvests apples and other technology news.</td>
<td>BBC</td>
<td>Online</td>
</tr>
<tr>
<td>Next chapter in the history of apples.</td>
<td>Pakenham Gazette</td>
<td>Newspaper</td>
</tr>
<tr>
<td>ROBOT.</td>
<td>9News</td>
<td>Television</td>
</tr>
<tr>
<td>Maryvale Energy from Waste Project.</td>
<td>OPAL ANZ</td>
<td>Online</td>
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<td>Development of fly ash-based SFRMs.</td>
<td>Western Sydney University Widevision</td>
<td>Online</td>
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9.6 Hub Finance

<table>
<thead>
<tr>
<th>REPORTING PERIOD</th>
<th>2021</th>
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<tbody>
<tr>
<td></td>
<td>INCOME</td>
</tr>
<tr>
<td>ARC</td>
<td>1,000,000*</td>
</tr>
<tr>
<td>Industry Partners</td>
<td>414,368</td>
</tr>
<tr>
<td>Universities</td>
<td>175,680</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,590,048</td>
</tr>
</tbody>
</table>

*Year 5 ARC cash contribution to the hub was fully received before 2021