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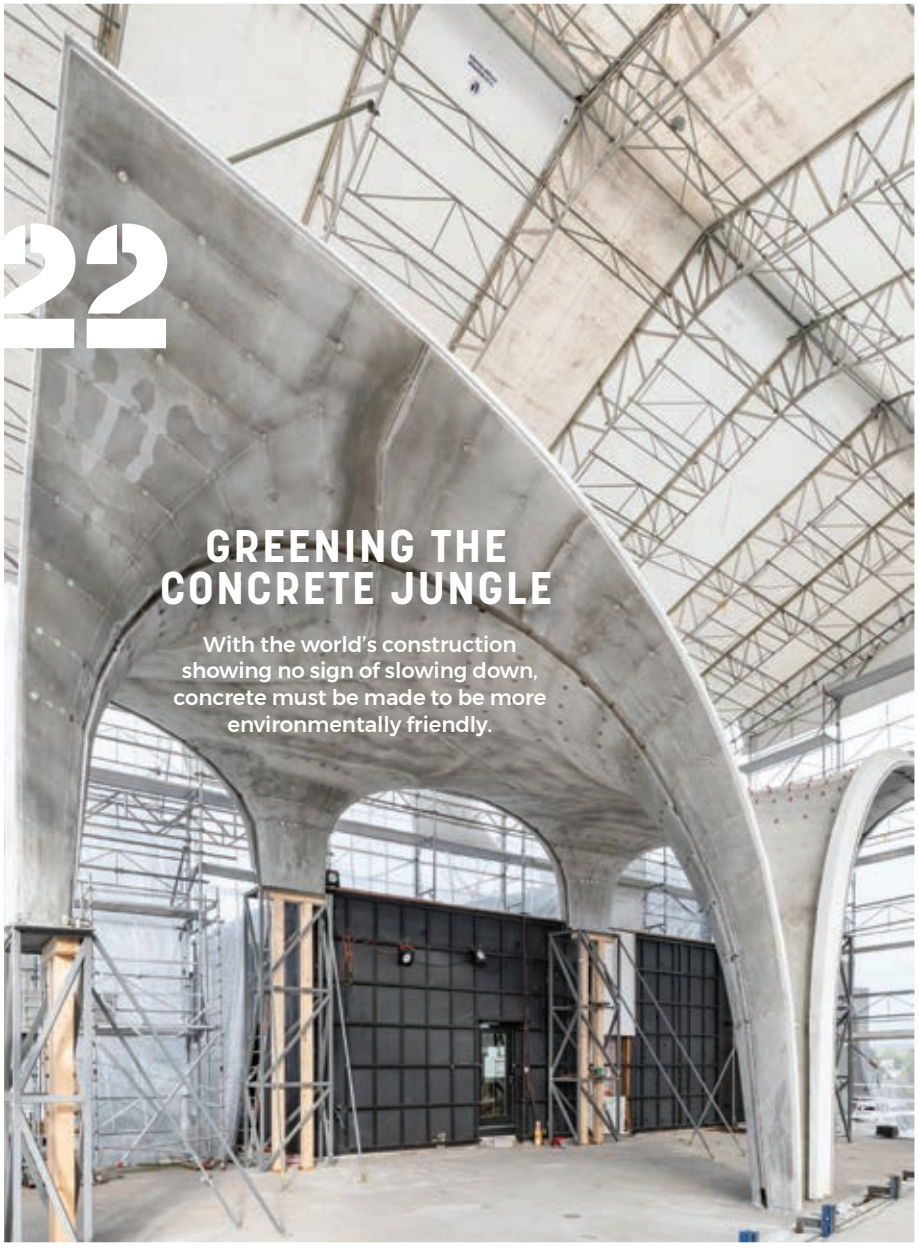

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GREENING THE CONCRETE JUNGLE

With the world's construction showing no sign of slowing down, concrete must be made to be more environmentally friendly.

IMAGE: ROMAN KELLER

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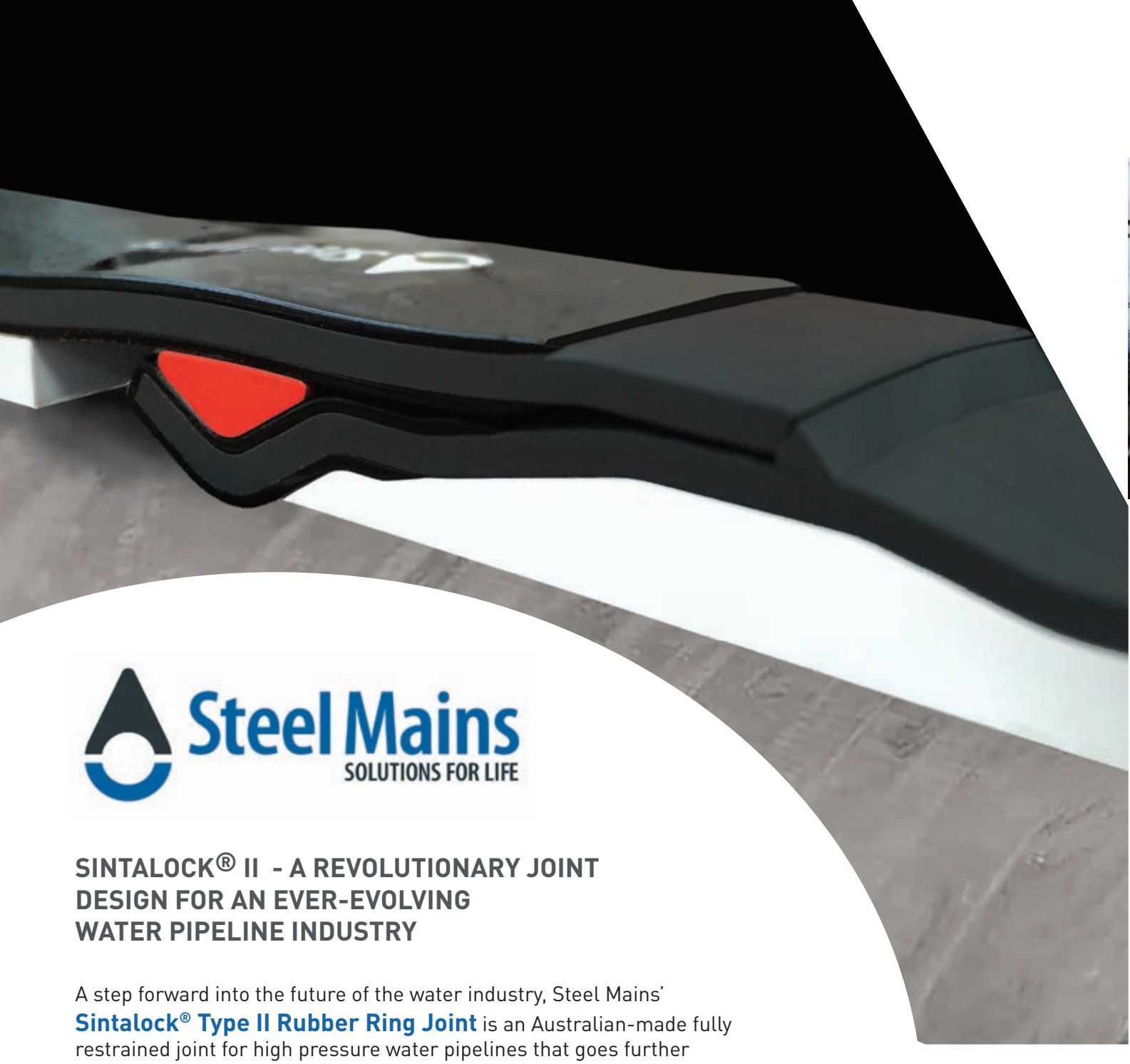

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Not-so-set in stone

FROM CONSTRUCTION TO TRANSPORT TO RENEWABLE ENERGY, THIS MONTH'S *CREATE* CONSIDERS A BROAD RANGE OF SUSTAINABILITY QUESTIONS.

WELCOME TO the August edition of *create*. This month's cover story is concrete — ubiquitous but historically significant and the second most used substance in the world.

Concrete, in all its grey glory, is facing a shake-up as experts explore its role in contributing to, and potentially addressing, climate change.

For many centuries, peoples the world over have designed and built structures from iterations of concrete, some still standing as testament to its durability and timelessness, as well as some impressive engineering.

But times are changing and concrete is changing too, an evolution intended to limit its ancillary effects, such as the environmental impact of sandmining and the demands placed on mineral resources by cement production.

Initiatives are underway to improve its lifespan and recyclability and increase its capacity to reduce waste going to landfill. Concrete is a crucial material for a modern world and the race is on to assure its future in an environment where every kilogram of carbon counts.

High-speed rail is a growing sector in many parts of the world, but debate has ebbed and flowed for decades in Australia about its feasibility here.

In this issue, read how commentators have long posited views on whether tracks that were laid for steam locomotives could accommodate a bullet train and if our population has the critical mass to warrant the capital expenditure such a project would entail.

What is not in dispute is that the route between Sydney and Melbourne is one of the busiest air corridors in the world and domestic air travel accounts for a disproportionate level of CO_2 emissions.

It stands to reason that reducing our reliance on air transport for passengers and freight and increasing our use of rail would aid Australia's endeavours to meet our net zero emissions targets.

But the issue has long been a political football with hurdles to overcome such as identifying and reserving an available corridor and the merits of a public-private partnership.

It is not in question that Australia has much technical expertise in rail infrastructure design and development, but we lack a mandate to capitalise on that skill with a high-speed rail project on home shores.

This issue also looks at the current state of wave energy generation on our abundant coastline.

Wave energy represents a renewable resource that researchers say is a more consistent, more predictable and higher density energy source than either solar or wind power.

But harnessing it is fraught with complexities that some top minds are working hard to overcome.

Meeting our renewable energy goals will take input to an optimised grid from a variety of sources, of which wave energy is a promising one.

We look forward to a future where Australian homes and businesses are powered by wave energy, particularly in remote regions.

Enjoy.

"Concrete, in all its grey glory, is facing a shake-up as experts explore its role in contributing to, and potentially addressing, climate change."

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DEBATE AND DISCUSSION BY *CREATE* READERS

Naval necessities

I was particularly interested in Chris Sheedy's most topical article "Deep Understanding" (*create*, June 2023) concerning AUKUS and especially the nuclear-powered submarine challenge.

In the article he quotes Vice Admiral Jonathan Mead as saying: "At the heart of the [nuclear-powered submarine] shipyard will be the key engineers, such as nuclear engineers, electrical engineers, electronics and mechanical engineers. We'll also need naval architects, communication specialists, materials engineers, environmental engineers, test evaluation and submarine systems and sensors engineers."

While I am in complete agreement with the statement that all of these engineering specialists will be required in significant numbers, and with the challenge of recruiting, training and retaining them, I take particular issue with naval architects being listed under the "also need" category when they should actually be at the very head of the "key engineers" listing!

Nuclear engineers, and all the other listed engineering specialists are essential to this enterprise but each one of them, apart from naval architects, are only concerned with one particular part of what makes up a submarine.

To produce a complete, effective, efficient submarine — or any other type of ship — and to keep it so throughout its working life, it is the naval architect who brings all the competing and often conflicting requirements together to produce the overall result required by the client.

It is naval architects who create ships — this is what we alone are trained for — and unless naval architects are appropriately embedded at all stages of the design, construction, setting to work, operation, maintenance and through-life support of these or any other vessels, the chances of failure are significantly increased.

Strong words, I know, but after a lifetime in the industry I feel I have seen it all and can speak with some authority. If we want our submarines to be "safe to dive" throughout their working lives then naval architects are the ones to establish and maintain that assurance.

JAMES M (JIM) BLACK CEng
PRESIDENT, AUSTRALIAN DIVISION
THE ROYAL INSTITUTION OF NAVAL ARCHITECTS

These are the writer's personal views.

"If we want our submarines to be 'safe to dive' throughout their working lives then naval architects are the ones to establish and maintain that assurance."

Wollongong work

I enjoyed the article "Green light for blue carbon" (*create* June 2023). The article made the point that Australia has a huge potential resource that will benefit Australia and the world.

Advantages of our blue carbon potential are that time to market is shorter than most other options and there are fewer supply chain issues. These points need to be made strongly to ensure both government and venture capital support.

An omission in the article is the failure to mention the long-term research programs running in the School of Earth, Atmospheric and Life Sciences at the University of Wollongong, led by Professors Kerrylee Rogers and Jeff Kelleway.

Not only are they exploring the dynamics of maritime carbon cycling, they continue to train significant numbers of geographers and scientists in this area, including field data collection and laboratory practices.

JON HINWOOD FIEAust

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welcomes feedback from the community

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- ☑ **clause 2.5.7.2.3 supply circuit discrimination with option for checking protective devices less than 250amps**
- ☑ **clause 5.3.3.1.1 protective earth conductor thermal stress check**
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THE ROYAL AUSTRALIAN AIR FORCE'S NEW HEAD OF GUIDED WEAPONS AND EXPLOSIVE ORDNANCE REACHED THIS THREE-STAR RANK THANKS TO HIS EXTENSIVE ENGINEERING EXPERIENCE.

FOR THE 102 years that the Royal Australian Air Force (RAAF) has existed, every member to achieve a three-star rank has been a pilot.

That changed this year on 8 May, when electronics engineer Air Marshal Leon Phillips was appointed as the Chief of Guided Weapons and Explosive Ordnance. The first non-war fighter to hold the rank, Phillips brings 36 years' experience to the newly created role.

"I think that says we've got an organisation that is realising that it takes a broad set of skills at the top of its organisation to be effective," Phillips told *create*.

"As an engineer, right from the get-go, my career has largely been partnering with industry to deliver new products or sustain those products to provide them to the war fighter."

Phillips's role arose from the Australian government's Defence Strategic Review. His job is to act as the single accountable officer overseeing the Australian Defence Force's strategy, capability, acquisition and development of guided weapons.

His particular focus, he said, will be on uplifting domestic manufacture, long-range strike capability and war stock holdings.

While Phillips is notable for not coming to this role from a combat position, he is by no means lacking in relevant experience.

Interested in computers as a child – when the technology was a curio rather than ubiquitous – he looked to the RAAF to sponsor his electronics engineering studies.

Imagining that he might serve for 10 years, he found instead a career's worth of opportunities unfurling before him.

"It feels like I've had 10 or 12 different jobs within that single career," he said.

"One thing the Air Force has offered me is a challenge and opportunity every three years as I've moved around, and then promotions that challenge and expand [my] horizons."

It was a series of posts to the United States, representing the Australian Defence Force in technological collaborations with industry, that really pushed him forward.

"I ended up moving overseas to St Louis to be the lead engineer of a development program to put modern electronics into our classic F/A-18 Hornet," Phillips explained.

"We put a tactical secure data link in the aircraft, brand new developed colour situational displays, a joint helmet mounted and queuing system that, depending on where the pilot looked, that's where it would queue missiles, and then software upgrades to go with that."

The collaborative work he did there – working with aerospace company McDonnell Douglas; the US government as a supplier; and ▸

ABOVE: Leon Phillips delivered the E-7 Wedgetail as part of the Airborne Early Warning and Control Program.

"ONE THING THE AIR FORCE HAS OFFERED ME IS A CHALLENGE AND OPPORTUNITY EVERY THREE YEARS AS I'VE MOVED AROUND, AND THEN PROMOTIONS THAT CHALLENGE AND EXPAND YOUR HORIZONS."

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the Canadian government as a partner and financial contributor – is how he found his "calling", Phillips said.

"I realised I really like doing this; I'm quite good at doing this," he said.

"That probably revitalised me and kick-started me into what's been a permanent career, largely focused on complex delivery programs or organisations that deliver complex systems to our war fighters."

Phillips's next big step came with a move to Seattle, where he took the helm as Engineering Manager of the Airborne Early Warning and Control Program. This involved delivering the E-7 Wedgetail, the first of its type for the RAAF.

"It was quite an ambitious project," he recalled.

"We had not put an electronically scanned array radar on an aircraft of that type, and we persevered through a lot of difficult technical challenges.

"But we accepted that aircraft in 2010, and here we are 13 years later and it's still a premier world-leading capability, the envy of the world.

"In fact, the US Air Force has only recently made a decision to buy two of those aircraft themselves in recognition of how [capable] that product was, so having an opportunity to be the lead engineer on a highly developmental project and work closely with technology leaders in that field was fabulous."

Working with such a diverse array of stakeholders expanded Phillips's worldview and helped him better understand how to bring disparate groups together.

"As an engineer, when you start out, you really just deal with other engineers," he said.

"You're really trying to understand your own category, your own skillset, your own profession. But then, very quickly, you end up having to work with adjacent skill sets, whether they're logistics officers, whether they're pilots, navigators, finance folks.

"WE ACCEPTED THAT AIRCRAFT IN 2010, AND HERE WE ARE 13 YEARS LATER, AND IT'S STILL A PREMIER WORLD-LEADING CAPABILITY, THE ENVY OF THE WORLD."

"So then, often, you're sitting there trying to make sure when you communicate with them, you are simplifying the language so it's not overly technical and trying to use a language that they can see themselves in or that resonates with them."

In his new position, Phillips is looking to identify industry partners to grow the Air Force's capabilities, create a purposeful team with understanding of the significance of its role, and to identify where resources should be focused.

"What's always excited me is ... the challenge and what is the mission, and do I feel I can add value and add something into that to make it better," he said.

"As long as I feel I can contribute in that space, then that's something that gives me a lot of energy." ●

JONATHAN BRADLEY

ABOVE (from top): Phillips meeting representatives of partner nations in Sydney; in his official Defence Force portrait.

Air Marshal Leon Phillips OAM

Current position:
Chief of Guided Weapons and Explosive Ordnance

Career highlights:
2022: Head of Aerospace Systems, Capital Acquisition and Sustainability Group
2019: Director General Business Relationship Management, Chief Information Officer Group
2017: Director General Aerospace Maritime and Surveillance, Capability Acquisition and Sustainment Group
2015: Officer Commanding, Surveillance and Control Systems Program Office, RAAF Base Williamtown
2008: Engineering Manager, Wedgetail Resident Project Team
2005: Chief Engineer, Aerospace Systems Division

Education:
- Executive Master of Business, Project Management, Queensland University of Technology
- Master of Project Management University of New South Wales
- Bachelor of Engineering (Electronic Engineering), University of New South Wales

WORDS BY **CHLOE HAVA**

HIGH-SPEED RAIL HAS BEEN AN ELUSIVE DREAM FOR AUSTRALIA, BUT SOME EXPERTS BELIEVE THE PATH TO NET ZERO SHOULD START WITH A BETTER CONNECTION FOR THE NATION'S MOST-TRAVELLED ROUTE.

FAST-TRACKED

WHEN IT comes to developing a high-speed rail (HSR) network, Australia falls far behind the curve.

The International Union of Railways defines HSR as a dedicated new track supporting trains moving at least 250 km per hour, or an existing upgraded track carrying trains up to 200 km per hour.

According to that definition, 20 countries have HSR networks, with construction underway in seven more, including Indonesia, India and Thailand. A further seven are in the planning stage.

However, Australia is only in the long-term planning phase, said University of Wollongong Associate Professor Philip Laird, a Fellow of the Chartered Institute of Logistics and Transport.

"We've conducted a lot of studies, at an estimated cost of $250 million, but not only do we not have one kilometre of track, we don't even have one kilometre of reserved corridor," he said.

There are historical reasons why rail projects continue to hit the skids, said Curtin University Professor Peter Newman, the Chair of the Intergovernmental Panel on Climate Change Transport Chapter.

"Around the world, bus, car, road and oil lobbies have constantly tried to undermine rail," he said.

In Australia, the political struggle also concerns the current composition of federal and state governments, with the Coalition less enthused by HSR development.

However, a major second rail revolution is now happening around the world due to the superiority of rail solutions, particularly as countries pursue net-zero carbon emissions.

"They're faster, better in terms of ride quality and safety, and you can build around them

FUTURE

ABOVE:
Peter Newman, Curtin University.

"WE'VE CONDUCTED A LOT OF STUDIES, BUT NOT ONLY DO WE NOT HAVE ONE KILOMETRE OF TRACK, WE DON'T EVEN HAVE ONE KILOMETRE OF RESERVED CORRIDOR."

so you don't sprawl your city," said Newman.

With rail-oriented Prime Minister Anthony Albanese now at the nation's helm, Laird thinks the planets are beginning to align.

"It's not going to come cheap or easy, but to make progress towards a 43 per cent reduction of emissions by 2030, we've got to move more freight and passengers by rail," he said.

And with every state besides Tasmania under a Labor government, Newman agrees now is the time for HSR.

"If ever there was going to be a chance to do it, it's when you've got a federal and majority state Labor governments."

AN EAST-COAST ROUTE

To demonstrate its commitment to HSR late last year, the Albanese government passed the High Speed Rail Authority Bill 2022.

This entailed establishing a High Speed Rail Authority, formed on 13 June 2023, with the independent body first tasked with advising the government on planning, development and oversight of the construction of an HSR network along Australia's east coast.

The authority will build on a 2013 feasibility study led by Albanese, who was Minister for Infrastructure at the time, that found it would cost $114 billion to construct a 1750 km east coast HSR line linking Brisbane, Newcastle, Sydney, Canberra and Melbourne.

This network, estimated to require 15 years of planning and 30 to construct, could allow passengers to travel between major cities and regional locales at speeds exceeding 250 km per hour.

"HSR will revolutionise interstate travel on the east coast, promoting sustainable settlement patterns and creating broad economic benefits for regional centres," a spokesperson from the Department of Infrastructure, Transport, Regional Development, Communications and the Arts told *create*.

The authority's first order of business is planning and corridor works for the Sydney to Newcastle section of the HSR network, backed by $500 million in government funding.

However, in Newman's view, the only way to ensure an HSR project of this magnitude has legs is through a value-capture model.

With funding for infrastructure projects increasingly hard to come by, coupled with governments' lack of expertise in land development, he believes private-public funding mechanisms are the way to go.

"There's an important principle about the requirement of private sector funding, so we can get proper development of stations

both in cities and along the way in regional areas, and really good town developments around them," he said. "There's also plenty of global money for net-zero projects, and all of these HSR proposals can be net zero."

ABOVE: Philip Laird, University of Wollongong. BELOW: The Tokaido shinkansen in Japan runs between Tokyo and Shin-Osaka.

TRAVELLING DIRECT

In Australia, domestic aviation was responsible for eight per cent of total transport emissions in 2019, and the Sydney to Melbourne route was the nation's most travelled.

In fact, this route was the second-busiest air corridor in the world pre-COVID, said Laird.

More than nine million passengers flew between the two state capitals in 2019 alone.

"IF WE'RE SERIOUS ABOUT NET ZERO BY 2050, WE HAVE NO OTHER OPTION THAN TO BUILD A SYDNEY TO MELBOURNE HSR TO REDUCE TRANSPORT EMISSIONS."

"If we're serious about net zero by 2050, we have no other option than to build a Sydney to Melbourne HSR to reduce transport emissions," he said.

However, Australia's steam-age alignment could throw a spanner in the works for developing an HSR line along this route.

Curvatures abound along the east coast, with the rail line between Sydney and Melbourne plagued by tight radius curves, along with 60 km of superfluous length.

"Much of that track was put down about 100 years ago to ease the gradients for steam locomotives, which had difficulty carrying heavier loads," said Laird.

"However, the gradients on many NSW lines slow down modern diesel or electric locomotives."

ONE LINK AT A TIME

Arguments against an Australian HSR network, including a 2020 report by the Grattan Institute, say the nation's cities are too small and dispersed to justify the financial and emissions expense of constructing bullet trains.

But Laird agrees with proposals to develop a faster Sydney to Melbourne rail line through a step-by-step process, where deviations eventually form part of an HSR network.

"One link can be done at a time, tying in with the existing one, with the old line left for freight or local passenger trains," he said.

Upgrading routes to allow for medium-speed rail could take just four years, and significantly cut travel time down between the two cities at a fraction of the cost.

"Detailed simulation by the University of Wollongong, reviewed by the Australian Rail Track Corporation in its 2001 Track Audit, found that if we construct three major deviations – from Macarthur to near Mittagong, Goulburn to Yass, and Bowning to Cootamundra – we only need 200 km of new track," said Laird.

"But you can bypass 250 km of steam-age railway." ▸

ABOVE: from the slides

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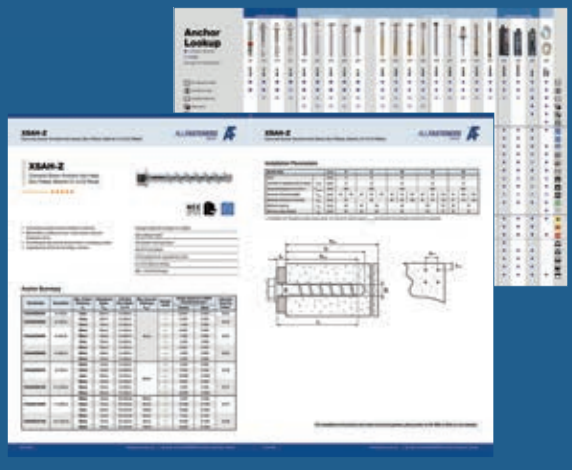

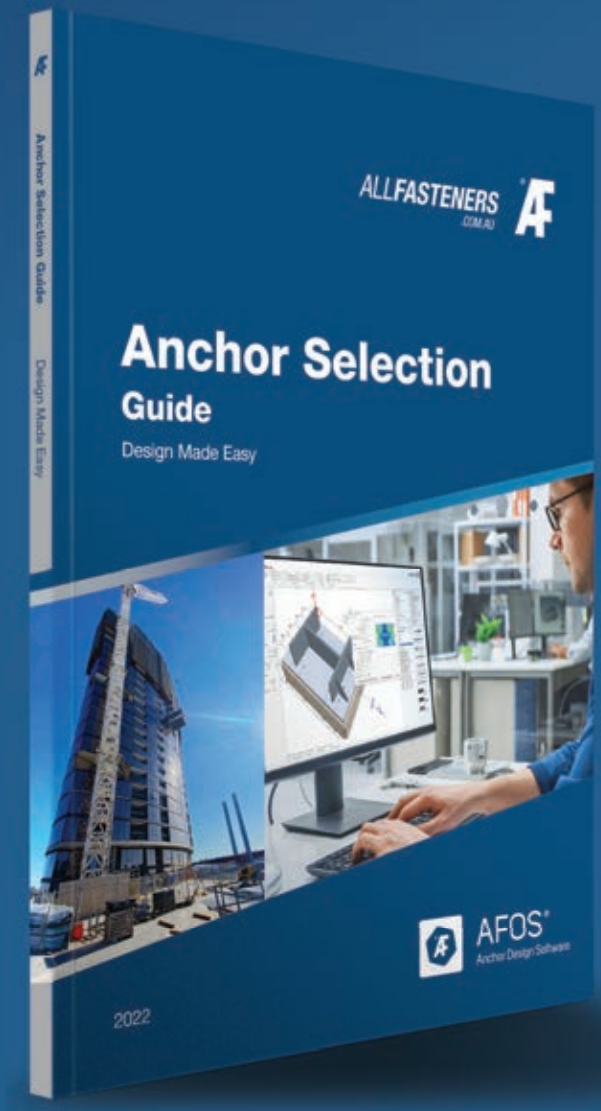

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"You can use a tilt train for a five-hour train service between Sydney and Melbourne at a lot less expense than building a dedicated HSR from Sydney to Melbourne," Laird said.

This would create significant freight benefits for rail share between Sydney and Melbourne, with rail now only carrying two per cent of the 20 million tonnes that moves between the two cities annually.

"To cut back on emissions, we really need to get some of that freight back on to the rail system, which is three times more energy efficient than trucks," said Laird.

Building rail's freight share up to 50 per cent would result in a 300,000 t reduction in emissions and 100 million litres less diesel burned annually.

More passengers travelling the route by rail instead of plane would also significantly reduce emissions from 185 kg of carbon dioxide to 76 kg of carbon dioxide per person.

Electrification could further cut emissions to under 50 kg of carbon dioxide per person, with infrastructure requirements for 25,000 V alternating current systems, including feeder lines and substations.

"The beauty of electrification is, if done properly, you generate electricity when trains go downhill," said Laird.

The rail line could even be solar powered, similar to Queensland's solar photovoltaic systems installed in 2021 at the Corinda Depot, Sunshine Integrated Material and Logistics and Gracemere Tilt Train Maintenance facilities, which generate 32,000 KWh of clean electricity annually.

"The solar would be provided at station precincts and around wherever the recharge goes back into the line," said Newman.

Without a Sydney to Melbourne high-speed route, the nation's largest metropolises are not accepting their roles as global cities, Newman thinks.

"Noisy cities full of emissions drive away capital and people," he said. "That's not something we can stand anymore." ●

"NOISY CITIES FULL OF EMISSIONS DRIVE AWAY CAPITAL AND PEOPLE."

High-speed rail: Australia's complicated history

High-speed rail (HSR) has been on the agenda in Australia for almost 40 years. Here are the proposals that have been suggested — and abandoned — over the decades.

1984
The CSIRO proposes a plan for a "very fast train" line operating between Sydney, Canberra, Gippsland and Melbourne at speeds of 250 km per hour on a dedicated track. Estimated to cost $2.5 billion, the scheme is deemed "uneconomical".

1986
The privately funded Very Fast Train Joint Venture forms, proposing an HSR line from Sydney to Melbourne via Canberra. Initially supported by Prime Minister Bob Hawke, the proposal fails to gain traction after tax changes to fund the project are rejected in 1991.

1993
Speed Rail Pty Ltd proposes HSR that would link Sydney to Canberra. John Howard's government encourages it in 1998, but lack of political support halts this proposal in late 2000.

2013
Julia Gillard's government initiates a two-phase feasibility study into an HSR network linking Brisbane to Melbourne via Sydney, Canberra and several regional areas. In 2013, Tony Abbott's newly elected government scraps the plans.

2019
The Coalition forms the National Faster Rail Agency, with a focus on trains travelling between 160 km per hour and 250 km per hour along upgraded tracks to connect major capital cities with key regional centres.

2023
Anthony Albanese's government establishes the High Speed Rail Authority.


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WORDS BY **CHRIS SHEEDY**

CONCRETE SOLUTIONS

CONCRETE IS THE SECOND MOST USED SUBSTANCE IN THE WORLD, AFTER WATER. WITH A CARBON-FUELLED CATASTROPHE ON OUR HANDS, SOMETHING'S GOT TO GIVE.

IMAGE: ROMAN KELLER

WHEN RENOWNED Italian engineer and architect Pier Luigi Nervi found global fame in the mid-1900s for his work with thin, concrete-shelled structures – including a boat hull – he did it by borrowing from the architecture of the ancient Roman and Renaissance periods.

Many historic cathedrals, for example, had been constructed using light concrete shells and stood for hundreds – and sometimes thousands – of years.

When Nervi was working, there were global crises and supply chain issues, with world wars and a boom in building projects. Certain building materials were difficult to procure. And so he made reinforced concrete his main structural material.

To do so, he used knowledge engineers had recently gained about the value of reinforcement, and also what those responsible for the Gothic architecture of the 12th to 16th centuries had discovered about the value of geometry.

Today, in a similar environment of supply chain squeeze and global crisis – this time environmental – Dr Philippe Block, Professor at the Institute of Technology in Architecture at ETH Zurich and co-director of the Block Research Group, is working to achieve parallel success. He, too, is looking into history to find solutions to modern-day challenges.

Block's design focus is also on thin concrete structures, but this time without reinforcing materials.

Why? For the same reasons that researchers and engineers around the globe are developing concrete alternatives and new concrete recipes: because we need to decarbonise.

Pound for pound, concrete is not a major offender. In terms of kilograms of carbon dioxide equivalent per kilogram ($kgCO_2e/kg$), concrete is equal to straw, at 0.1 $kgCO_2e/kg$. Rebar comes in at 1.2, steel is 2.7, brass is 4.5 and aluminium is 11.5 $kgCO_2e/kg$.

BELOW (clockwise from top): A Pier Luigi Nervi-designed shell; an arched 3D-printed concrete masonry bridge by the Block Research Group; constructing the bridge.

"GLOBAL BUILDING FLOOR AREA IS EXPECTED TO DOUBLE BY 2060: THE EQUIVALENT OF ADDING AN ENTIRE NEW YORK CITY TO THE WORLD, EVERY MONTH, FOR 40 YEARS."

IMAGE: STRIATUS

The problem comes from the amount of concrete poured. As reported by *Architecture 2030*, global building floor area is expected to double by 2060, adding about 240 billion square metres. That's "the equivalent of adding an entire New York City to the world, every month, for 40 years", the report said.

To even come close to current net-zero goals, engineers, researchers and construction professionals must attack the problem on a number of fronts. ▸

GREENING THE JUNGLE

Most of the carbon footprint of concrete comes from the manufacture of limestone-based cement, said Dr Rackel San Nicolas, Senior Lecturer and Academic Leader of the Geopolymer and Minerals Processing Group at the University of Melbourne.

San Nicolas is currently driving research into what she refers to as the "greening of the concrete jungle" by creating better concrete.

"Cement represents eight per cent of global carbon emissions," San Nicolas said. "You can make sustainable concrete in different ways, but at the core it's about reducing the amount of Portland cement used.

"The main approach I've been using is to utilise different waste materials like fly ash or slag, or different processed material like calcined clay, that have a much lower CO_2 footprint."

A transition to what is known as geopolymer concrete, San Nicolas said, would be relatively simple in Australia, as there is already a stockpile of more than 400 million tonnes of fly ash – waste from the coal industry – 30 per cent of which is appropriate quality for use in concrete. There is also more than 500 years' supply of clay that can be calcined.

Cement-free concrete, and concrete with just 50 per cent cement, is available in the market right now. It might be used for retaining walls or other less structurally important projects. But confidence is yet to be built in products engineers can design with.

"It's a very big hurdle for engineers and project designers to build confidence in these materials," San Nicolas said. "But more suppliers are saying that by the end of this year they will have concretes we can design with, and we will have more full-scale trials and data around their durability."

Also assisting in the clearance of this hurdle is the SmartCrete Cooperative Research Centre (CRC), which exists to enhance industry-research collaboration.

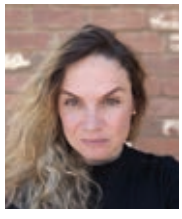
"We co-invest with industry in research projects that are innovative and generate impact by transitioning concrete for a sustainable Australia," said Clare Tubolets, SmartCrete CRC's CEO.

"We focus on decarbonising concrete across three research programs, taking a lifecycle carbon approach.

"The first is about sustainability, looking at the concrete mix itself, but also including elements of recyclability. The second is engineered solutions, thinking about how you design structures to optimise concrete use and reduce the carbon load overall.

"The third is asset management, focusing on understanding and improving the health of existing concrete infrastructure through sensing and data analytics.

"If we can extend concrete life, we replace it less frequently." ▸



ABOVE: Dr Rackel San Nicolas, University of Melbourne. LEFT: San Nicolas's work creating less carbon-intensive concrete.

"YOU CAN MAKE SUSTAINABLE CONCRETE IN DIFFERENT WAYS, BUT AT THE CORE IT'S ABOUT THE MANUFACTURING OF CEMENT."

ABOVE: Clare Tubolets, SmartCrete CRC.

When in Rome

Why is it that today's concrete-based builds can crumble within decades but some of Rome's glorious buildings and infrastructure are still standing — and, in the case of several aqueducts, still working — thousands of years on?

The secret lies in the Roman concrete's built-in self-healing properties, recent research has revealed.

A report published in *Science Advances* explains that Romans employed hot mixing of concrete "using quicklime in conjunction with, or instead of, slaked lime, to create an environment where high surface area aggregate-scale lime clasts are retained within the mortar matrix".

These quicklime clasts remained as reactive calcium, meaning that when a small crack formed and water ran through that crack, a calcium-saturated solution was formed, recrystallising as calcium carbonate and filling the crack.

The research team created its own hot-mixed concrete containing quicklime clasts, cracked the casts and ran water through them. Within two weeks, the cracks had healed.

With such spectacular science involved in the construction, it's no wonder Rome wasn't built in a day.

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LESS MATERIAL

The primary objective of using concrete in engineering and construction will always be concerned with risk, said Tubolets.

"We don't want our structures falling down," she said. "If there is a decision between sustainability and durability to be made, durability will always come first."

Here is where Block and his disruption of concrete construction comes in. He believes we can have both sustainability and durability, and he points to ancient cathedrals across Europe, still standing today, as evidence.

"Historically, there was at some stage a shift between cost of labour and material. Material became very cheap and labour very expensive," Block said.

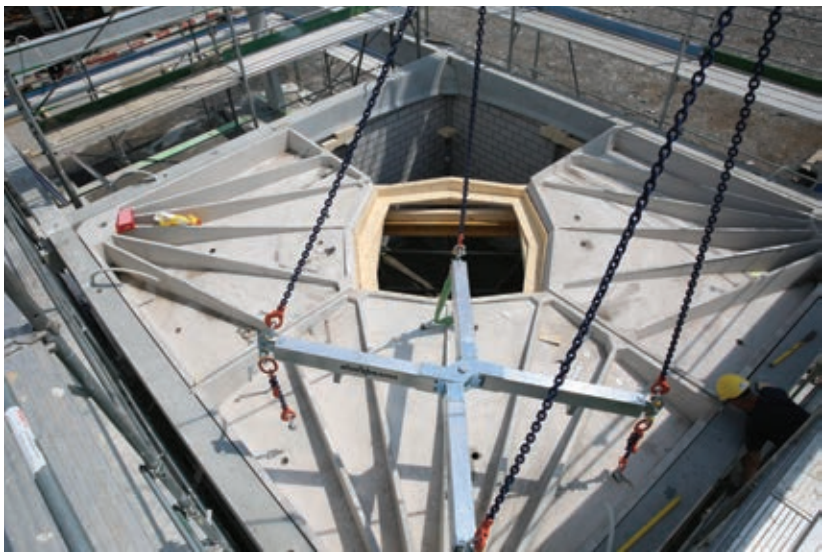
"There was also an aesthetic change with mid-modernism and its straight lines. People no longer liked curved arches and vaults. Then we started to optimise and to look at productivity.

"WE DON'T WANT OUR STRUCTURES FALLING DOWN. WHEN THERE IS A QUESTION BETWEEN SUSTAINABILITY AND DURABILITY, DURABILITY WILL ALWAYS COME FIRST."

"All the systems around construction and engineering evolved in one direction and we lost the structurally informed geometries that made sense for a certain material, and that also demanded a certain craft. We also lost the tools to design and engineer those."

And so we reached a status quo, Block said – one that has been difficult to challenge. But today, that is fast changing.

Block and his team have been working on the design and production of a concrete floorplate system that reduces the amount of concrete required by up to 70 per cent, and the amount of reinforcing steel by up to 90 per cent. It's a system that turns concrete floor pieces into a sort of concrete masonry – reusable, replaceable and removable many times over.



ABOVE: Block Research Group's floorplate system reduces concrete and steel use.

"This is nothing new," he said. "It's just reintroducing the same principles behind why Gothic cathedrals are still standing."

"We started a spin-off called Vaulted to commercialise these floorplates that are now built into a couple of projects. We have reduced materials so much, embodied emissions are reduced by 85 per cent."

Interestingly, there's no green premium in terms of cost for the floorplate system. Most of the benefit comes from getting the geometry right. The rib-stiffened floorplates are designed essentially as a thin funicular vault of unreinforced concrete supported by a series of spandrel walls, which act as vertical stiffeners. They handle weight the same way the roof of a cathedral does.

With the correct geometries, and the materials savings across all floors of a building, specifically in the foundations, the system can be cost-neutral while hitting high sustainability targets, Block said.

The concept of concrete masonry also creates an inherently flexible building system. Flexibility for future use, said Paul Easingwood, Director, Structures and Facades at Bligh Tanner, is now an essential ingredient in construction.

"You can make a relatively small investment to lift a building

BELOW: Dr Phillippe Block, Block Research Group.

one or two grades in terms of yield and rental income, breathing another 30 or 40 years of life into a concrete frame," he said.

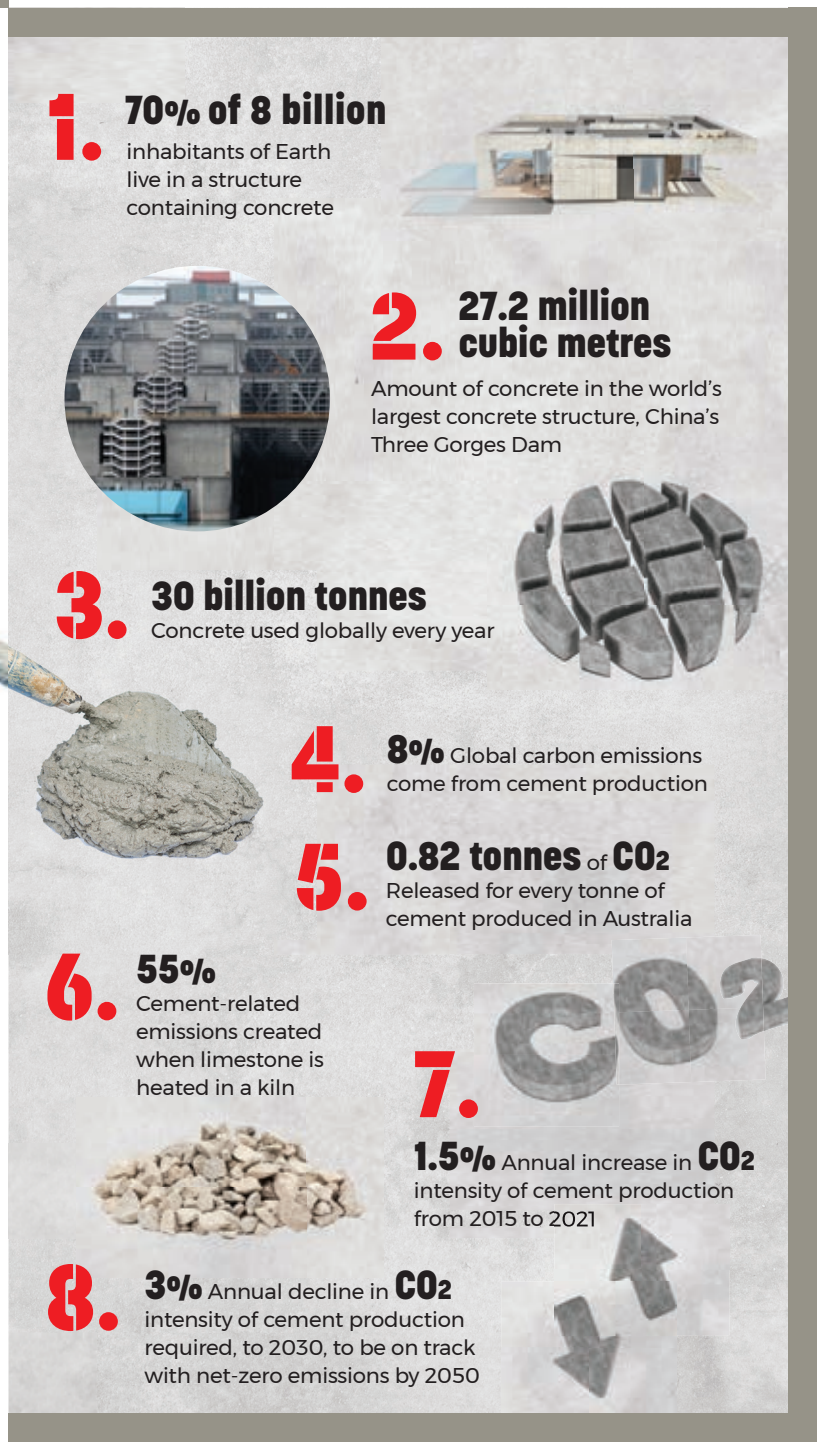
"You don't have to go through that financial and environmental expense of demolishing 40 storeys of concrete, then pouring another 40 storeys of fresh concrete. What's really important is making sure that core building can change its purpose."

DIFFERENT MATERIALS

There are various options that can be added to the materials mix, Easingwood said. While none will ever replace concrete, they can be used to reduce our reliance.

Timber in its various forms is becoming a more frequent ➤

CONCRETE BY THE NUMBERS



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The West Gate Bridge Project

Dulux® Protective Coatings is proud to have partnered with McElligotts on one of Australia's largest steel maintenance projects – the West Gate Bridge.

Built in the 1970's, this Melbourne icon was coated with Dulux Protective Coatings and now 40 years on it was time for a remediation project.

Exposed to pollution from traffic and sea water the West Gate Bridge required superior protection. For the 800m-long steel deck, Dulux Protective Coatings along with Mark Dromgool of KTA-Tator Australia specified a four-part coatings system, plus a special stripe coat for more than 120,000 bolts!

After extensive product trials by the McElligotts team, Dulux's durable system was chosen as the fastest drying solution with the best finish. Here are the steps in our specification:

BLAST: The 800m long steel deck had a total of 60,000 square meters to repaint. The underside of the steel deck was abrasive blast cleaned.

PRIME & FIRST COAT: Zincanode® 402 was applied with a Cold Cure Hardener. The two-pack epoxy zinc rich primer is ideal for use over abrasive blast cleaned steel.

SECOND COAT: The second coat of surface tolerant epoxy Durebild® STE was then applied.

THIRD COAT: Durebild® STE MIO added a layer of surface tolerant micaceous iron oxide, working as a barrier coat for protection against water ingress.

FINISH: A final topcoat of Weathermax® HBR MIO ensured a high build finish.

selection, as is steel framing, particularly with the potential modularity they can offer.

"We're doing a number of schools projects in New South Wales, which are modular," Easingwood said. "It's a mandate from School Infrastructure NSW. A lot of those systems are using timber, timber framing or cross-laminated timber.

"Ten years ago, that wouldn't have been a conversation. Every day of the week it would have been a two-storey concrete frame. But now, there's a heavy momentum to steer the construction industry toward different paths."

New engineering challenges also arise with new materials, around construction methodologies, tolerances, procurement and accuracy.

"With long delivery times for some materials, it requires a different mindset to fix a lot of the design elements early and make sure everyone understands they cannot change those elements," Easingwood said.

"Then there are new problems to solve. How does this timber work? How does it shrink? How do we connect it? How do we build earthquake design into it?"

While different and new materials are a welcome addition, Tubolets said, it's important not to lose focus on the improvement of concrete and reinforcement.

"Concrete is always going to play a vital role in the built environment, so we need to consider more sustainable ways of using it. Research in engineered solutions is considering new generations of reinforcement to help reduce or remove the steel component and move to carbon or plastic fibres," she said.

"At the same time we're looking at recycling other industrial waste products into concrete as aggregate, including crushed glass, crumbed rubber and recycled concrete."

"YOU CAN MAKE A RELATIVELY SMALL INVESTMENT TO LIFT A BUILDING ONE OR TWO GRADES IN TERMS OF YIELD AND RENTAL INCOME, BREATHING ANOTHER 30 OR 40 YEARS OF LIFE INTO A CONCRETE FRAME."

ABOVE: A drain in Brisbane converted to a natural waterway, with the concrete reused in the park.

IMAGE: EPOCA

REUSE AND RECYCLING

Speaking of recycling, Tubolets said, the first stage of a successful circular economy framework is the most simple: do nothing.

A Bligh Tanner project in Hanlon Park, in Brisbane's Stones Corner, attracted much positive attention for doing almost that.

When a 500 m concrete drain was dug up and turned into a natural waterway, the concrete pieces taken out of the ground were used elsewhere in the park, as retaining walls, as seating areas and to armour parts of the new creek. Very little of the concrete went to landfill.

A great deal of work is now being done around recycling concrete itself, and on using those materials to create concrete that is just as durable as the virgin mix. Professor Vivian Tam from Western Sydney University, Director of the Centre for Infrastructure Engineering, is a leader in this ▸

field, having developed a product known as CO_2 Concrete.

Tam has spent many years perfecting CO_2 Concrete, produced by injecting carbon dioxide into recycled aggregates to accelerate the carbonation process. It improves binding and boosts the durability and strength of the recycled concrete.

Not only does the final product match performance of virgin concrete, she said, it also costs less, reduces carbon emissions, sequesters carbon permanently and is compatible with carbon capture technologies.

"We have been working with a lot of companies, including Holcim, Sika, AW Edwards, Mott MacDonald and Bouygues via the Holcim Accelerator Program Season 3," Tam said.

ABOVE: Vivian Tam, CO_2 Concrete. TOP: A building crew using CO_2 Concrete.

"I HAVE SOME PARTNERS SAYING THAT EVEN IF CO_2 CONCRETE WAS MORE EXPENSIVE THAN NORMAL CONCRETE, THEY WOULD STILL USE IT BECAUSE OF THE GREAT BENEFITS."

EXPERT FINDINGS

At a recent Engineers Australia roundtable focusing on the circular economy and attended by representatives from industry and government, concrete was a central discussion. Among the ideas considered were:

BETTER CONCRETE

Current situation: The concrete industry responds to minimum standards, not regulation, and those minimum standards vary from state to state due to available materials, and different climatic conditions. Just as important as better concrete is some level of consistency in the concrete standards across Australia, given local constraints. Perhaps a regulatory framework could provide the basis for better concrete.
Possible improvements: There are examples of low-carbon concrete being developed (such as Envisia by Boral), revolving around the idea of replacing concrete content with low carbon materials, while maintaining strength and longevity profiles.

REUSE AND RECYCLING

Current situation: On the whole, used concrete typically ends up as landfill or recycled aggregate, gravel or stones for concrete mixes, backfill and drainage. This largely depends on the availability and cost-effectiveness of landfill charges on one side and recycling centres on the other, given transport costs.
Possible improvements:
One aspect worth keeping an eye on in this space is design for deconstruction, in particular modulation of form, making it easy to assemble and disassemble. This is becoming increasingly important as a design issue.

The use of landfill and recycling centres will need to be reviewed through incentives, regulation, compliance and certification systems.

USING LESS CONCRETE

Current situation: There are few alternatives that compare economically with standard concrete. Most other products on the market require premium payment.
Possible improvements: Further research and development into low-carbon concrete products developed and funded from pilot to market commercialisation. If a single company did this, the outcome would not be as positive as it will if numerous businesses create competition and economies of scale. In some projects, concrete has been replaced with other materials, as is the case for Lendlease's timber tower at 25 King Street, Brisbane.

"I'm now looking into other waste, such as brick waste, that can be recycled into concrete."

There is change in the air, Tam said. Having dealt with an industry that was previously reluctant to transform, her work is now receiving a great deal of attention.

"I have some partners saying that even if CO_2 Concrete was more expensive than virgin concrete, they would still use it because of the great benefits," she said.

While this acceptance of change is a positive, what is required now is cross-sectoral collaboration, Tubolets said.

"To certify a building for 50 years, we'll need to work together to gather a lot of data on the products that are used," she said. "We are risk-averse in this sector for very good reason. But we're moving in an excellent direction toward the future of concrete." ●


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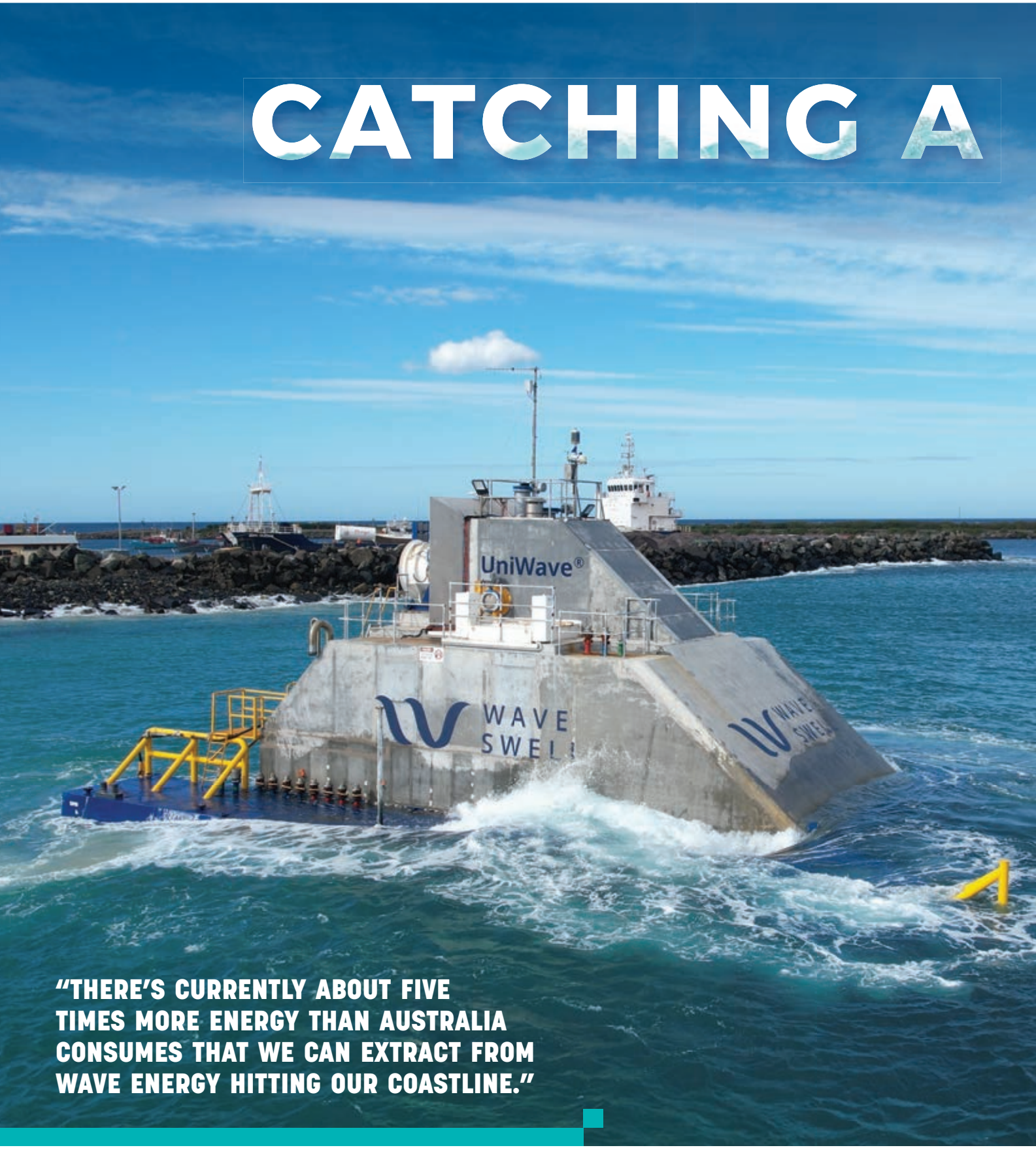


"THERE'S CURRENTLY ABOUT FIVE TIMES MORE ENERGY THAN AUSTRALIA CONSUMES THAT WE CAN EXTRACT FROM WAVE ENERGY HITTING OUR COASTLINE."

WORDS BY **ELLE HARDY**

WAVE

THE CONSISTENCY AND PREDICTABILITY OF WAVE ENERGY MEANS IT COULD PLAY A BIG ROLE IN IMPROVING THE RELIABILITY OF GRIDS POWERED BY RENEWABLES. WHAT WILL IT TAKE TO HARNESS SUCH AN ABUNDANT RESOURCE?

ABOVE: Scott Hunter, Wave Swell. LEFT: Wave Swell Energy's project on King Island, Tasmania. RIGHT: Jonathan Fiévez, Carnegie Clean Energy.

AUSTRALIA'S 25,780 KM of coastline provides access to abundant, untapped potential energy from the sea.

Not only do waves have the highest energy density compared to other renewables – by some estimates, five to 10 times greater than wind and solar – they are more consistent and predictable.

The CSIRO's Wave Energy Atlas shows that the southern coastline of Australia has a significant wave energy resource that could provide ideal conditions for wave energy production.

The agency's research also found that wave energy could contribute up to 11 per cent of the response to Australia's energy demand – enough to power a city the size of Melbourne by 2050.

Furthermore, marine renewable energy is one of the fastest-growing sectors globally.

The "resource is undeniable", as Jonathan Fiévez, mechatronic engineer and CEO of Carnegie Clean Energy put it. And a number of recent studies from the CSIRO and other groups have proved that.

"There's currently about five times more energy than Australia consumes that we can extract from wave energy hitting our coastline," Fiévez said. "The energy is there, crashing on the shore every day of the week."

Fiévez said that wave energy provides an amazing opportunity for a country like Australia, given the "incredibly consistent resource we have to fill that gap, especially as we get towards 70 to 80 per cent solar and wind penetration".

One case in point is the 2022 research by Australia's national science agency, which was commissioned by Wave Swell Energy and concluded that harnessing wave energy off the coast of southern Australia would deliver more stability and reliability to a future clean electricity grid, as well as reduce the cost of batteries to store this renewable energy.

More predictable and consistent than solar and wind, wave power can also deliver commercial advantages, including by powering hybrid renewable models that require less than half the capital expenditure of a system with solar, offshore wind and battery storage alone.

Wave Swell's Chief Technical Officer, Scott Hunter, told *create* that the study showed that even though their technology is not currently as cheap as other

renewables, considerable savings could be made by complementing wave energy with other renewable generation. That's because it reduces the amount of storage required to meet demand.

Hunter also noted that in the future, costs will drop, "and we will be competitive in our own right".

Yet despite decades of attempts, wave energy hasn't seen large-scale commercialisation. To find out why, ›

create took a deep dive into the world of wave energy.

BREAKING BARRIERS

The wave-energy process is relatively simple: waves form as wind blows across the surface of water, creating kinetic energy. Wave-energy converters then capture this clean energy and transform it into electrical power.

Yet the extensive timeframe for technology development, as well as the large associated capital funding requirement, makes it incredibly difficult for an individual company to secure the funds to scale its technologies for commercialisation, said Stephanie Thornton, General Manager of the industry-founded Australian Ocean Energy Group.

"Attracting R&D investment is also difficult," she told *create*.

"As wave and tidal technology developers are maturing their technologies, the path to commercialisation – and customer identification – is not always clear."

Compared to heavy government investment in other emerging energy sources, Australia lags when it comes to funding emerging wave-energy technology, especially compared to countries such as Spain and the United Kingdom.

"The geographic distribution of the ocean energy and where electricity needs to be distributed for end use are many times located far apart," Thornton said, "leading to development challenges such as establishing a supply chain, permitting approvals, establishing shoreside infrastructure support and more."

Australia's wave resources are primarily distributed throughout the southern part of the continent, with the Great Southern Ocean home to some of the most potent wave power in the world. Its tidal power is almost perfectly positioned, largely along the north-eastern and north-western regions, as well as parts of Victoria and Tasmania.

BLUE ECONOMY

Thornton believes that the best near-term market for ocean energy technologies are "blue economy" end users such as ports, aquaculture, remote communities, desalination operators and integrated microgrids.

"It's hard to compete with the scale of offshore wind production at the gigawatt level," she said.

Therefore, targeting "blue economy markets" provides the industry a more immediate opportunity to deploy wave and tidal technologies as part of a commercialisation strategy.

The cost of energy is an important metric by which the maturity of ocean energy technologies is measured.

Thornton argues that the current approach, which indicates the technology's competitiveness in reference to a levelised cost of energy, creates an inaccurate understanding.

"Instead, a realistic measure of the cost competitiveness is to evaluate the cost of energy production from a specific technology or technology system – such as a microgrid – against an end-user's cost of energy supply," she said.

"AS WAVE AND TIDAL TECHNOLOGY DEVELOPERS ARE MATURING THEIR TECHNOLOGIES, THE PATH TO COMMERCIALISATION – AND CUSTOMER IDENTIFICATION – IS NOT ALWAYS CLEAR."

ABOVE: Stephanie Thornton, Australian Ocean Energy Group.

Energy production for a specific wave device might not be considered cost-competitive with solar or wind; however, Thornton said that on places such as islands, where there is a need to transport and store diesel to supply to end users, the energy supplied by ocean power could deliver cost savings and reduced environmental risks.

"There is no one-size-fits-all technology," she said, because the use of ocean energy provides a wide range of solutions.

"I'd like to see our industry start to think about who the first-adopter markets are, and what types of technology are going to be best suited for solutions for those end users."

Thornton is bullish on microgrids, which can be scaled to provide deliberative energy for particular situations.

"You can set one up to supplement an industrial port with huge energy demands by allowing ships to connect to it when they first dock," she said.

"Or, in remote communities and Indigenous communities – places that are often suffering energy poverty – these systems can be deployed."

ENGINEERING SOLUTIONS

Chris Shearer CPEng, principal engineer and technical lead at maritime-oriented consultancy firm BMT, agrees that Australia's coastal communities, which currently rely on high-cost fossil fuel generation such as diesel generators, are good candidate locations for wave energy and other renewable sources.

"I'D LIKE TO SEE OUR INDUSTRY START TO THINK ABOUT WHO THE FIRST ADOPTER MARKETS ARE, AND WHAT TYPES OF TECHNOLOGY ARE GOING TO BE BEST SUITED FOR SOLUTIONS FOR THOSE END USERS."

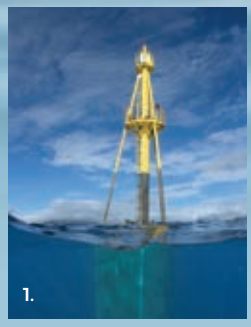
However, setting on the right technology remains an issue for the industry.

"One of the challenges with wave-energy technology is the lack of convergence of the style or type of wave energy conversion technology, contrasted against wind energy which has converged on a single preferred technology style," he said.

Shearer, who represents Engineers Australia on the Standards Australia national committee for marine energy converters, said that one of the most studied types of wave energy converter is the oscillating water column, which was recently used on Wave Swell's King Island project.

WAVE ENERGY CONVERTERS: A FIELD GUIDE

Wave energy converters are devices that convert the kinetic and potential energy from passing waves into mechanical or electrical energy to power the grid. There are seven main converter types currently in use worldwide: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1. Point absorbers are floating buoy structures which absorb energy from any direction on the water surface, converting the wave action at a single point into electrical power.

2. Submerged pressure differential is a submerged point absorber that exploits the pressure difference between wave crests and troughs as waves pass above it. The submersion may help the devices survive storms. In Australia, Carnegie Clean Energy's core product is CETO, a submerged point absorber technology that is targeted towards utility-scale generation.


2.


3.

3. Oscillating water columns, featured in Australian projects such as King Island, use waves to force a column to move up and down like a piston, forcing air in and out of the chamber. The machinery is usually in an L-shape and sits out of the water.

4. Attenuators look like two modular barges linked like wings, where the flexing joints generate power. These are deployed parallel to the direction of wave travel. They can be several metres wide and hundreds of metres long and will be used in the M4 project off the coast of Albany, Western Australia.


4.

5. Terminators, or overtopping devices, operate similarly to a hydroelectric dam. They raise a volume of water to a height above the ocean's surface and use the potential energy difference, much like the wave action found on a beach.

6. Oscillating wave surge converters sit on shallow seafloors, using a pendulum arm flap to pivot on a hinged joint as the wave rolls over them, allowing the device to oscillate back and forth. The flap can then be mechanically linked to a pump to pressurise fluid, or a generator to produce electricity.

7. Rotating mass devices usually sit on the surface and drive a rotational alternator creating mechanical energy as the device tries to reach equilibrium.

"This style of converter permits a column of water to rise and fall within a chamber, which, in turn, pushes and pulls air through an air turbine circuit," he said.

"All of the machinery is out of the water."

Internationally, oscillating water columns have been popular, and are able to be integrated into marine structures. Shearer points to the Mutriku facility in Spain which has been successfully operating since 2011, and Scotland's LIMPET project, which began in 2000 and connected to the United Kingdom's national grid.

Columns are not the only technology in play, with Australian-founded firm Bombora, which recently relocated to Europe, using a submerged pressure-differential style of wave energy converter.

"It essentially consists of a structure on the seafloor, which has integrated air bladders, which compress in sequence under wave action, driving an air turbine circuit, all underwater," Shearer said.

BMT, which has acted as an independent technical expert reviewing projects on behalf of the Australian Renewable Energy Agency (ARENA), is also getting involved with design itself as part of the Albany M4 wave energy research and development project. This will construct, deploy, operate and retrieve a 25 m long floating and articulating wave energy converter off the southernmost coast of Western Australia.

There, Shearer said, they will have to overcome one of the major engineering challenges of wave energy: successfully deploying devices.

"There's been a number of examples of failures of projects at the deployment stage," he said.

"It's important that the marine operations phase is well engineered and reviewed with the appropriate due diligence."

The reliability of electrical and mechanical equipment is another challenge, he said, as "wave energy machines are required to work in a corrosive saltwater environment, which is prone to extreme weather events".

Ocean energy also presents logistical barriers, as engineers and technicians typically can't simply go out to the machine whenever they need to.

"Obtaining suitable weather windows to enable safe access to the wave energy converter for commissioning, maintenance, operations and retrieval can be challenging," Shearer said.

"In recent years there have been issues in decommissioning various previous wave energy projects, either due to lack of funding, or challenges associated with obtaining suitable weather windows to perform the necessary decommissioning activities."

In the short term, Shearer said that wave energy's future will likely be in niche applications such as island communities, end-of-grid communities, offshore infrastructure such as aquaculture, and oil and gas operations.

"However, as the industry develops further, there may be opportunities to, for example, integrate wave energy with offshore wind, and provide a meaningful contribution to the main electricity grid," he said. ●

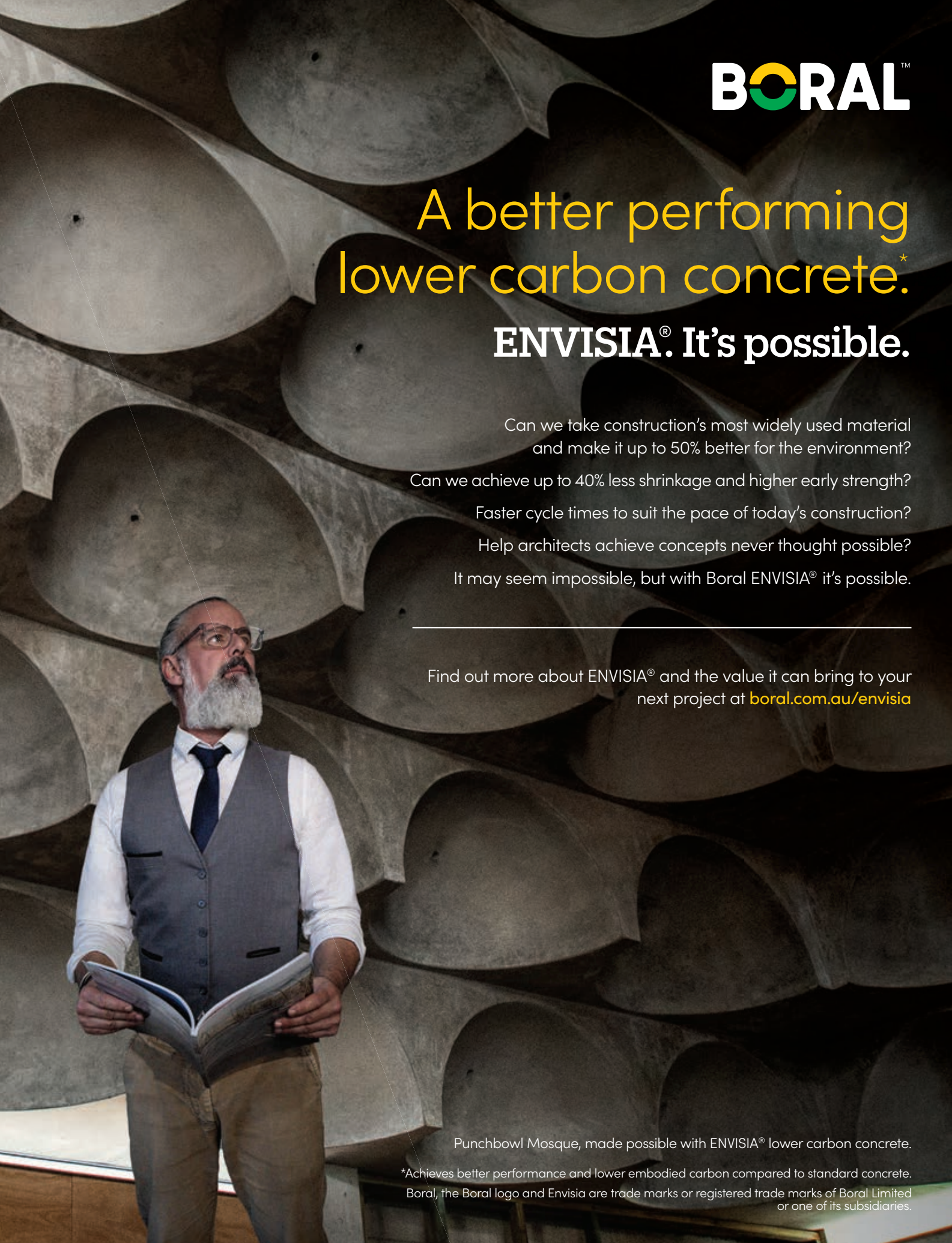
"WAVE ENERGY MACHINES ARE REQUIRED TO WORK IN A CORROSIVE SALTWATER ENVIRONMENT, WHICH IS PRONE TO EXTREME WEATHER EVENTS."

ABOVE: The Australasian Coasts and Ports Conference features a tour of the Noosa Coast.

THE AUSTRALASIAN COASTS AND PORTS CONFERENCE

The Australasian Coasts and Ports Conference on the Sunshine Coast this month brings together pre-eminent industry leaders to highlight the persisting importance of coastal engineering problems. The program includes:

- Pre-conference workshop on the feasibility of shore power to decarbonise our ports.
- A two-day coastal engineering short course conducted by UNSW Sydney's Water Research Laboratory prior to the conference.
- Three technical tours, an exploration of the Noosa Coast, including a visit to the Huon Mundy Oyster Reef, an operational and navigational tour of the Mooloolaba River and Maroochy River Groynes, and an investigation of the Bribie Island breakthrough that has reshaped the area.



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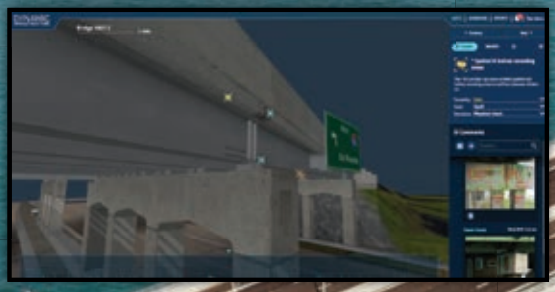

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INNOVATION TOWARDS ZERO

WORDS BY **MICHELLE WHEELER**

HIGH VALUE

TECHNOLOGIES SUCH AS ROBOTICS, ARTIFICIAL INTELLIGENCE AND 3D PRINTING ARE RAPIDLY CHANGING THE WAY HUMANS CREATE. CAN AUSTRALIA SEIZE THE UPPER HAND IN ADVANCED MANUFACTURING?

IN A FACILITY on the outskirts of Geelong, a team of engineers is refining technology that could one day feature in the next generation of fighter jets.

They're integrating thin-film solar cells into carbon composite sheets, building a single aircraft part that is both structural and a solar panel.

Other research in the building is exploring composites for hydrogen storage and harnessing the conductivity of carbon fibres to create a battery from an aircraft wing.

The facility is the research and development arm of Quickstep, an Australian manufacturer producing advanced composites for defence, commercial aircraft and drones.

The company's contracts include parts for Super Hercules military transporters and F-35 Joint Strike Fighters. It's intricate, high-tech work.

"It's a much more complex process than just pouring steel or aluminium in a mould, or smashing it in a stamping die," said engineer Luke Preston, Quickstep's Head of Technology and Partnerships. "You've got to build it up and layer in a really specific way to get your strength."

Carbon fibre is 14 times as strong as steel, but only in one direction, Preston said.

"On average, you roughly get half the weight for the same strength," he said.

Composites also make it easier to manage any damage.

"In metal, if you get a crack, as you vibrate and move that part, the crack will propagate," Preston said. "However, if you get a crack and some damage in your carbon fibre … the damage doesn't grow over time."

Preston said composites can also have other materials embedded into them.

"[In] aircraft, you often have copper mesh to protect for lightning strike," he said.

ABOVE (from left): Quickstep's advanced composites are used in drones; the company's Geelong facility.

ABOVE (from top): Luke Preston, Quickstep; Romilly Madew, Engineers Australia.

"Or you can put Kevlar-style materials in if you want to help ballistic protection."

It's the kind of manufacturing the country will need more of if Australia is to revive its ability to make world-class products at home.

INDUSTRY 4.0

In the first industrial revolution, steam power was used to mechanise production. For the second, electricity created mass production. The third, or digital, revolution automated it.

The fourth is expected to blur the lines between the physical, digital and biological worlds.

Engineers Australia Chief Executive Romilly Madew said the fourth industrial revolution is being led by economies that have harnessed artificial intelligence and the Internet of Things to optimise data exchange in their manufacturing processes.

That presents Australia with an opportunity.

"Australia has an effective window to build on our use of Industry 4.0 technologies in advanced manufacturing to compete with low-cost manufacturers from other countries," Madew said. "Our ranks of highly skilled and qualified professionals give us an advantage in the niche product space."

"IT'S A MUCH MORE COMPLEX PROCESS THAN JUST POURING STEEL OR ALUMINIUM IN A MOULD, OR SMASHING IT IN A STAMPING DIE."

Earlier this year, the Australian government launched an inquiry into advanced manufacturing.

"Advanced manufacturing in Australia is bigger than people think, at $100 billion annually and hundreds of thousands of jobs," Madew said. "And there are still great gains to be made."

One Australian business that has embraced advanced manufacturing is Breseight, a precision engineering company founded in 1983. Over the years, it has diversified to offer services including 3D printing and laser sintering, before launching medical device offshoot BresMedical.

The company collaborated with European oral and maxillofacial surgeons to develop ImplaNav, a system that improves the accuracy and safety of dental implant surgery.

It is also commercialising personalised joint replacements and a range of orthodontic cutters.

Breseight Managing Director Kevin Cullen, the son of one of the company's founders, said its medical devices path began with 3D-printing technology. ▸

"We just followed the line of where the products could be used," he said. "And basically brought in technology and education to get us down that path of innovation."

Part of Breseight's strategy has been to partner with research organisations, and the company collaborates with universities in Australia, the US and Europe.

Cullen, who trained as a mechanical engineer, said the first challenge was to bring new standards into the company, such as the ISO 13485 certification for medical devices. But one of the hardest things was getting the company's existing workforce up to speed.

Staff had to transition from working in a contract shop to producing innovative medical devices.

"You're going from an old school-type knowledge to a higher level," Cullen said.

"[It was] just a different way to think for the company."

WORKFORCE CHALLENGE

Dr Cori Stewart is the founder and chief executive of the Advanced Robotics for Manufacturing (ARM) Hub, a not-for-profit supporting Australian manufacturers.

She's worked with hundreds of local businesses looking to integrate robotics, artificial intelligence and other Industry 4.0 technologies into their operations.

Cullen's training challenge is something Stewart has seen again and again as companies seek to modernise their manufacturing processes.

"It usually is a workforce challenge," she said.

Stewart said the ARM Hub aims to design solutions with the people working on the floor.

"They're the experts, because they know what success looks like; they know what they've got to produce at the end," she said.

Stewart said it can help to allay people's fears about losing work, no longer being good at their job, or not being relevant.

"And we know, by putting them at the centre, they will then be much more likely to use the technology that comes out the other end," she said.

"They'll have a sense of ownership, they will have designed it, and they will have been trained in it through that process."

"ENGINEERS ARE PRIZED IN THIS SPACE, PARTICULARLY THOSE WHOSE COMMUNICATION SKILLS ARE HONED FOR SALES AND THE ABILITY TO APPLY TECHNICAL DETAIL AND TALK THROUGH END-USER BENEFITS."

Madew agrees it's a challenge for businesses to keep up with the rapid pace of technology and keep their workforce ahead of the curve.

She said micro-credentials can provide an opportunity for engineers to rapidly upskill in fast-developing areas of Industry 4.0.

"It's an option that offsets the overhead of investing heavily to study technology that is evolving rapidly," Madew said.

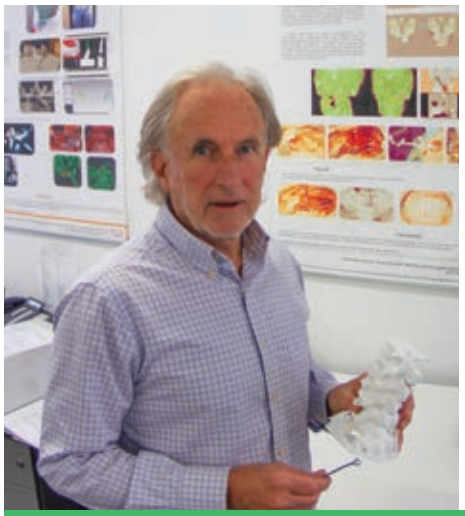
"And it's very effective at fostering cross-skilling so engineers from different disciplines have a path into advanced manufacturing, as well as high-value transferable skills."

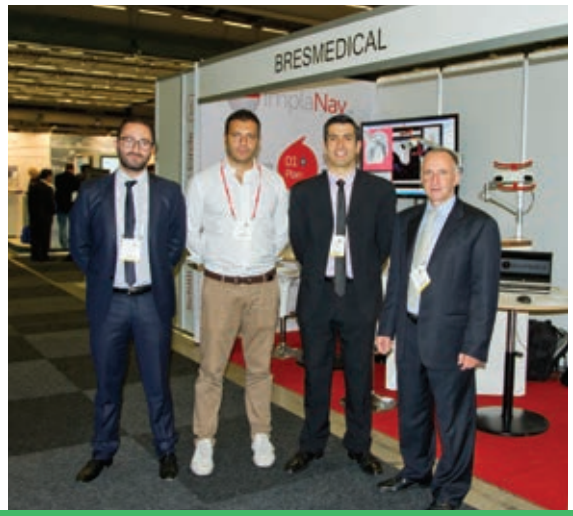
Madew said areas for businesses to upskill include innovative design, technical leadership, reliability and post-production intangibles, such as after-sales service.

"Engineers are prized in this space, particularly those whose communication skills are honed for sales and the ability to apply technical detail and talk through end-user benefits," she said.

MANUFACTURING MYTHS

Preston, who started his career at Ford and spent four years at Tesla before returning to Australia, believes two "easily believable but really untrue" misconceptions about manufacturing are limiting the country. ▸





BELOW (from left): Kevin Cullen, Breseight; Cullen (far right) with staff from Breseight offshoot BresMedical; Dr Cori Stewart ARM Hub.

Coates

ENGINEERING SOLUTIONS

5 reasons to choose Quadshore™ 150 over conventional propping systems

Designed by engineers at Coates and Monash University, Quadshore 150 is the lightest, heavy-duty propping solution in the world. Here's why you should consider hiring it for your next project.

1. Stronger, yet lighter than conventional systems

Conventional propping systems are often costly and inefficient due to their low capacity-to-weight ratio and bolted module-to-module connections. Quadshore 150 uses lightweight, high-strength steel elements to provide extra-high load-bearing support of up to 170 tonnes. The working load limit-to-weight ratio of a 3m assembly is at least 1.7 times higher than conventional systems.

2. Faster and easier to install and de-install

Quadshore's patented boltless connectivity eliminates the need for consumables. As a result, assembly and disassembly time is at least 60% quicker than conventional systems with the same capacity. A range of end sections means adjustments are faster and easier, too. These include an unloading jack that enables the screw jack to be disengaged with zero manual effort.

3. Safer due to less manual handling

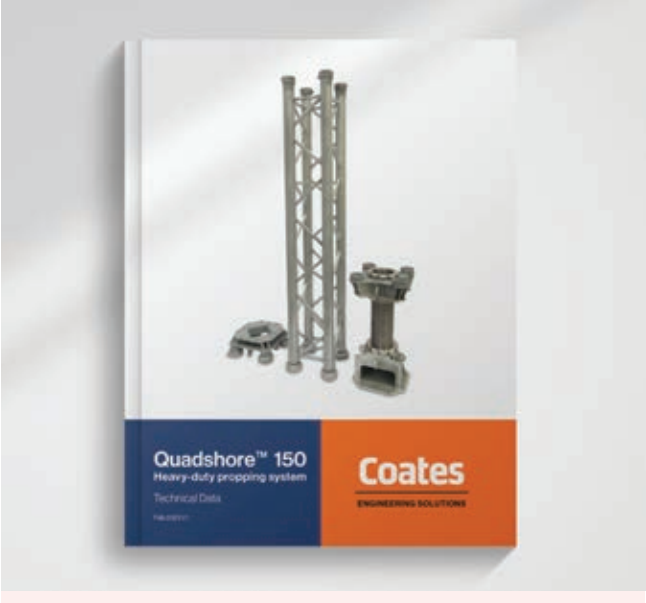
Conventional propping systems pose challenges around safety due to the need for manual handling and heavy machinery or equipment to unload and install it. As Quadshore 150 is considerably lighter with no bolted connections between its modular beams and a smaller site footprint, Coates expects the number of lost time injuries reported by customers will be dramatically reduced.

4. Reduced costs for labour, transport and consumables

Compared with a conventional propping system, Coates estimates that Quadshore 150 will reduce transport costs due to its lighter weight and higher capacity, which means less equipment, machinery and labour are required on site. The boltless design will also result in significant cost savings on consumables throughout the entire lifecycle of the product.

5. Lower carbon footprint due to less transport

Quadshore 150 is more environmentally sustainable than conventional propping systems in a number of ways. As it is made with higher-grade steel, there is less material used in its manufacture and less energy is required for its transportation. Boltless connections mean less waste of any kind of steel componentry.



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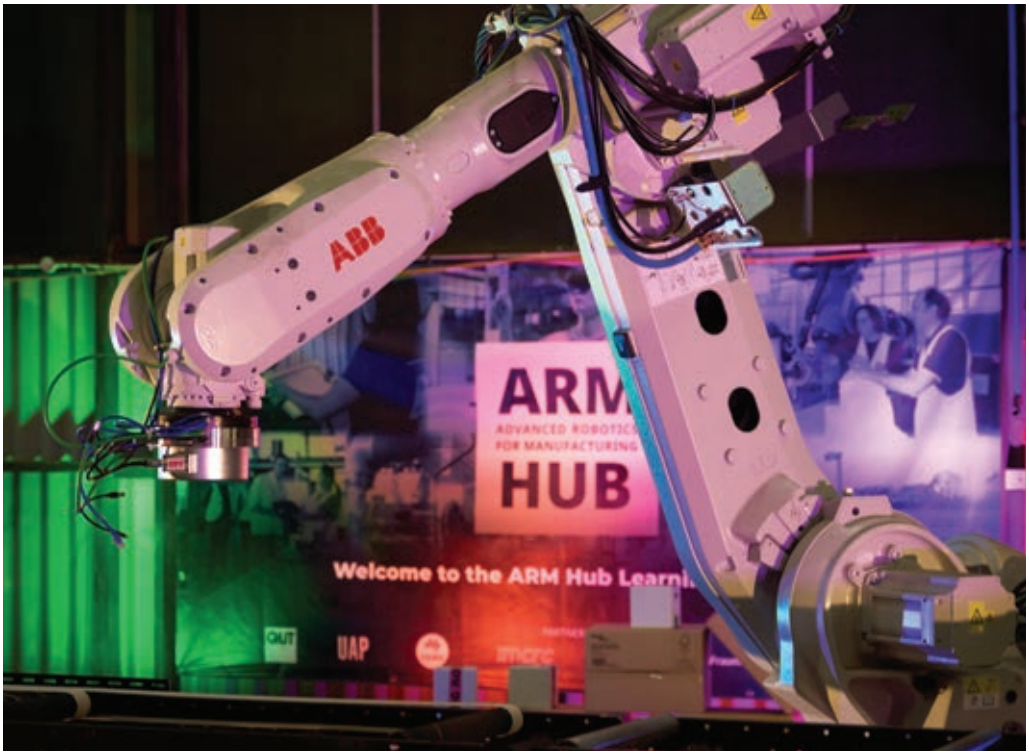

The first is the idea that manufacturing is low-tech.

Preston said when the automotive sector shut down in Australia it was made to appear as a knuckle-dragging industry.

"Now companies like Tesla are leading the world through technology, through a car company," he said. "We need to really grow our appreciation of it."

The second misconception is that Australia is too small a market and shipping products around the world is prohibitively expensive.

"I think that's a big falsity, because the dirt gets shipped as unrefined dirt, as iron ore," Preston said. "Battery materials [lithium and copper] get shipped as unrefined materials."

Preston said Australian minerals might be sent to China for refinement, then the US or Europe for manufacturing, before being delivered back to the local market.

"If you did a full study of the full lifecycle of dirt to product, the best way to deliver that product would be to add all the value next to the hole where you dug your dirt," he said. "I think there's such an opportunity. We need to be adding the value and using that to grow the country significantly."

"ENGINEERS NEED TO BE THE NEW SURGEONS. WE HAVE TO BUILD REALLY FAST, WE HAVE TO INVEST REALLY QUICKLY, AND WE HAVE TO HAVE OUR EAR TO THE GLOBAL MARKET."

THE "NEW SURGEONS"

Stewart said advanced manufacturing needs a wide range of engineering and design capabilities, including electrical and mechanical engineers.

"The engineering base is fundamental," she said.

"And it's hard to be able to recruit fast enough across industry."

Stewart thinks Australia should celebrate engineers the way they're celebrated in places like Germany.

"I think they need to be the new surgeons," she said.

"We have to build really fast, we have to invest really quickly, and we have to have our ear to the global market." ●

ABOVE: An ARM Hub co-bot.

THE "MOST IMPORTANT COMPANY IN THE WORLD"?

It's the most valuable tech firm in Europe, and its top-end product sells for about $270 million. But most people have never heard of Dutch manufacturer ASML.

ASML makes the machines that are used to produce microchips. All major chip producers employ the company's technology, which uses light to print tiny patterns on silicon wafers in a process called lithography.

These tiny pieces of silicon are the foundation of the digital world. They're found in products including computers, smartphones, appliances, gaming consoles, medical devices and weapons.

It has led some to label ASML the most important company in the world, and to put it at the heart of a chip war between the US and China.

ASML's machines work by projecting light through a blueprint of a pattern and on to a photosensitive silicon wafer. This process is repeated until the wafer is covered in patterns, completing one layer.

To make a microchip, the process is repeated 100 times or more, laying patterns on top of patterns. Different types of lithography machines are used for different layers, with new systems printing smaller features.

These more advanced machines have been the target of US efforts to limit China's access to chip-making technology.

In 2019, under US pressure from Donald Trump's administration, the Dutch government withheld an export licence enabling ASML to sell its top-of-the-line "extreme ultraviolet" lithography machines to China's main semiconductor foundry.

US President Joe Biden's administration has pushed for additional restrictions that would rein in exports of advanced versions of ASML's older "deep ultraviolet" technology.

NEXT LEVEL


RAIL
CROSSING
2
WAY
TRACKS
STOP
ON RED
SIGNAL
KEEP
TRACKS
CLEAR
RAILWAY
CROSSING

WORDS BY **CHRIS SHEEDY**

FOR ITS WORK ON VICTORIA'S LEVEL CROSSING REMOVAL PROJECT, LAING O'ROURKE IS ADDRESSING THE CHALLENGE OF CLIMATE CHANGE BY EMBRACING NEW PRODUCTS AND PROCESSES.

A **SENSE OF** urgency is driving change at Laing O'Rourke right now, said Hollie Hynes, the company's General Manager, Sustainability and Environment.

The urgency is driven by the organisation's Global Sustainability Strategy, set in 2021.

That strategy has already influenced change on sites around the globe, including in the processes the company followed and the materials it has chosen.

In August 2021, for example, Victoria's Department of Transport and Planning (DTP) confirmed that, for its its Level Crossing Removal Projects (LXRP), it would approve on a case-by-case mixes with a higher proportion of cement replacement than allowed in its standards.

Specifically, the Australian Roads Research Board (ARRB), on behalf of DPT approved a mix with 70 per cent cement replacement with industrial by-products such as fly ash and slag. This is 30 per cent higher than the 40 per cent limit in the standard and 55 per cent higher than the LXRP business-as-usual (BAU) rate of 15 per cent.

This change, which will prevent the emission of about 4000 t of carbon dioxide over three sites, might have been impossible had there not been a program alliance model in place, one that encompasses collaborative contracting.

And with the LXRP project having now grown to 110 crossings, the positive effect should scale significantly.

"In a traditional contract model, you go to tender and businesses bid and the bidders that don't win are reimbursed," Hynes said. "It's roughly a four to five-month process to even bid the job and a nine-month process to be awarded. If you did that for 110 projects consecutively, we'd still be bidding in 2090 and beyond. So the client has been smart and wrapped this up into a program alliance, which helps accelerate the work."

There are a lot of efficiencies to be gained from doing several projects at the same time, and from the same alliances moving on to the next projects.

In the Laing O'Rourke alliance, known as the South-East Program Alliance (SEPA), are LXRP, Jacobs and Metro Trains Melbourne.

"We've completed six level crossings to date, including four at the beginning that weren't formally part of the alliance program," Hynes said. "We also have another five we have been awarded that we are developing with the client.

"Three of the projects in delivery are using this mix, showcasing how we are able to create sustainable solutions that have ongoing benefit, not just for LXRP but the broader industry.

"WHEN YOU ARE IN A PROGRAM ALLIANCE, AND THE CLIENT IS IN THE TENT WITH YOU, THERE ARE NO BARRIERS TO SHARING INNOVATIONS OR IDEAS."

"That's the second important point of this collaborative contracting model. When you are in a program alliance, and the client is in the tent with you, there are no barriers to sharing innovations or ideas, and we're incentivised to put everything on the table.

"It fosters an environment in which innovation, sustainability and early adoption are incentivised and rewarded financially, so innovations are shared and best practice quickly spreads across sites.

"I cannot stress enough how contract models are going to be the maker or breaker of the transition to 2050." ▸

"INNOVATIONS ARE SHARED AND BEST PRACTICE QUICKLY SPREADS ACROSS SITES. I CANNOT STRESS ENOUGH HOW CONTRACT MODELS ARE GOING TO BE THE MAKER OR BREAKER OF THE TRANSITION TO 2050."

TRIED AND TESTED

Such a model was also a success when used by the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) in the years following the 2011 New Zealand earthquake.

On that project, numerous stakeholders were "in the tent", including Canterbury Earthquake Recovery Authority, Christchurch City Council, NZ Transport Agency, and engineering and construction firms City Care, Downer, Fletcher, Fulton Hogan and McConnell Dowell.

Businesses were rewarded for adhering to a set of performance measures that included innovation and collaboration. Cost penalties were shared among all teams, meaning high performers were incentivised to boost the success of others.

ABOVE: Laing O'Rourke introduced more environmentally friendly concrete mixes into its construction.

The result was a higher pace of recovery for the city as well as greater innovation.

"There has been a lot of innovation in Christchurch since the earthquake," Professor Suzanne Wilkinson, now with Massey University, but at the time Director of the Centre for Disaster Resilience, Recovery and Reconstruction, said in a 2016 interview.

"The first is around SCIRT and the way it uses an alliance approach to take on a massive horizontal rebuild. That, in itself, was an innovation. Without SCIRT, Christchurch's recovery would have been much slower.

"SCIRT also set a key performance indicator for innovation, for each building team. This was one of the KPIs linked to the reward of future work packages. It meant innovation was very visible and helped foster innovative practices … it was also exciting for us, as the innovation KPI created over 600 innovations for us to research."

LOW-CARBON CONCRETE

Did the use of concrete containing a lower-carbon cement mix – one produced with 70 per cent of its cementitious material replaced with fly-ash and slag – bring engineering challenges?

"There are some differences," Hynes said.

"But one of my team members, when I was talking with them about it, said it was quite unremarkable in itself.

"There's a programming consideration because it takes longer to cure initally. It's not horrifically slow, but it does need to be taken into consideration."

During the pilot program to test the new mix, it was poured in the sub-structure. This was most suitable, as piles are often poured early but are not load-bearing until later in a program.

This gave the team time to allow the concrete to cure and to further test its properties.

In many ways, the lower-carbon concrete was better than the business-as-usual mix. ▸

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"It's more durable with regards to chemical attack and corrosion and its lower heat of hydration, while reducing early age strength development, reduces risks from thermal cracking as the concrete sets," Hynes said.

"This mix could be used for slabs – it can be designed to meet all the key performance requirements – however, we would need to conduct more investigations and possibly implement more controls."

The team started with the biggest opportunity area for this project: the piling.

"If it's proposed for use in a slab, it has higher finishing requirements and can't be loaded for a longer time period. We need to start factoring that in when we budget," Hynes said.

"You can still use it, but what's most important is that we're now very comfortable in using these mixes for substructures."

ALLIANCE HELP

Laing O'Rourke worked closely with the SEPA team to identify the concrete mix, its use cases, and a supplier, Holcim Australia.

The client, having been a part of the entire discussion, authorised the concession to use the mix.

Once tested on the live project, which was the Union Road and Mont Albert Road level-crossing removal project, it was immediately approved for use for piles on the next three projects.

On these, 50 per cent of the concrete, or about 18,000 m^3, will be in piling.

LEFT: Laing O'Rourke's team working on the Level Crossing Removal Project.

"IT'S MORE DURABLE WITH REGARDS TO CHEMICAL ATTACK AND CORROSION AND REDUCES RISK OF THERMAL CRACKING."

"Our sustainability team and our engineering team worked out the areas of greatest materiality in this job and over the next three jobs," Hynes said. "We were able to make some decisions that were going to have large, scalable impact rather than impact on just one job. We chose concrete.

"The client's maturity and confidence around the importance of this has evolved along the way. It went from incentivising Green Star and Infrastructure Sustainability Council ratings to incentivising the areas of real materiality – reduction in tonnes of carbon – and saying actually, we're now incentivising you to find solutions that don't exist at the moment."

For Laing O'Rourke itself, a powerful part of its sustainability journey so far has been in developing an understanding of its own emissions profile.

"Scope one and two emissions are well known for us – fuels and electricity – but scope three is much more difficult. They are the emissions that result from the activities of assets not owned by us," Hynes said.

"We committed to truly understanding our scope three in 2019 and realised that it is now 95 per cent of our emissions profile.

"Concrete – and I know this is a big estimate – is responsible for 20 to 50 per cent of scope three our emissions. And we believe it's at the higher end of that scale.

"That's why we decided on concrete as our first area of focus, and that's why we're so proud of our progress so far." ●

Better building

Laing O'Rourke is not only using lower-emissions concrete in its work on Melbourne's Level Crossing Removal Project.

On the Central Station Main Works in Sydney, 51 per cent of cement replacement across all the concrete used is produced with supplementary cementitious materials (SCM).

Client Sydney Metro is keen to have contractors use concrete mixes with a reduced carbon footprint. All concrete used in the project's Metro tranche must contain SCMs like fly ash or slag, following specific requirements.

In addition, on Western Australia's Metronet project, which encompasses 21 km of bridges and five stations, the current use of SCM runs at 52 per cent. It is mainly used on stations as kerbing and ground slab.

Laing O'Rourke's MELconnx team is sharing these discoveries with the company's Byford Rail Extension project team, also in Western Australia.

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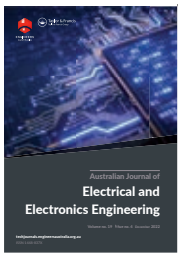
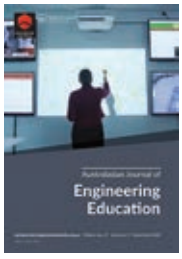


A RISK-BASED MACHINE-LEARNING APPROACH FOR PROBABILISTIC TRANSIENT STABILITY ENHANCEMENT INCORPORATING WIND GENERATION

Journal: *Australian Journal of Electrical and Electronics Engineering*
Author: U. Shahzad

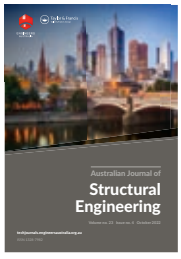
Power systems are becoming more complex than ever and are consequently operating close to their limit of stability. Due to its significance in power system security, it is important to propose a novel approach for enhancing transient stability that considers uncertainties. This paper advances a risk-based, machine-learning decision-making approach.



A TAXONOMY OF COMMON ENGINEERING ACTIVITIES AND COMPETENCIES

Journal: *Australasian Journal of Engineering Education*
Authors: E. Crossin, J.I. Richards, S. Dart & K. Naswall

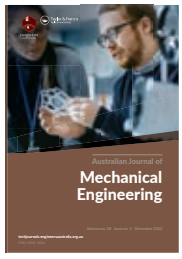
This paper addresses the lack of a unified approach to understanding engineering practice by developing and presenting a taxonomy of common engineering activities. The taxonomy provides a critical foundation for better understanding what engineers do, particularly in the Australian and New Zealand context, and has potential utility in both engineering practice research and engineering education curriculum reform.



REVIEW OF TIMBER CONNECTION DESIGN IN AUSTRALIA

Journal: *Australian Journal of Structural Engineering*
Authors: A. Amirsardari, J. Lee, E. Gad & L. Pham

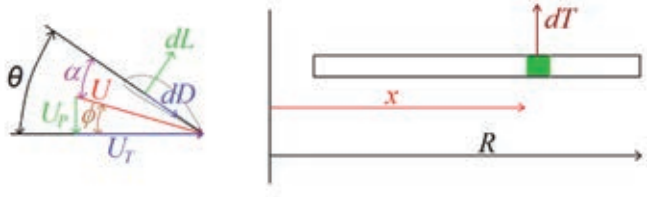
This paper reviews previous research and current practice in timber connection design in Australia with reference to methods of deriving design information from test data for nails and screws. The supply chain for timber connections has changed with a reduction in the use of timber species and an increase in new fasteners developed for specific purposes. A new approach to the design of timber connections has been proposed to cope with the changing situation.



Dynamic analysis of a helicopter blade subjected to the aerodynamic loads based on Euler-Bernoulli beam theory

Journal: *Australian Journal of Mechanical Engineering*
Author: H. Raissi

This research examines the vibration of a helicopter blade, based on Euler-Bernoulli beam theory. The paper concludes that the blade deformation will be oscillating in terms of time, and it is very sensitive to the control parameters, its geometry and the environmental conditions. The aerodynamic forces are introduced in terms of the pilot parameters, including the collective pitch, lateral cyclic, longitudinal cyclic and built-in twist on the blade deformation. Moreover, the effects of the blade rotational angular velocity, flight altitude, the blade length and induce velocity on the blade deflection are studied. The results show that the blade deformation will be oscillating in terms of time and is very sensitive to the control parameters, its geometry and the environmental conditions.



BELOW RIGHT: **The cross-section view of the helicopter blade with applied forces.**

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15-18 AUG 2023
AUSTRALASIAN COASTS AND PORTS

Location: in-person *Sunshine Coast*
Website: *coastsandports2023.com.au*
The theme, "Working together: 50 years of coasts and ports", will bring together professionals to focus on the technological, scientific, policy, planning and design issues related to our diverse and developing coasts.
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07-08 SEP 2023
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Location: in-person *Brisbane*
Website: *engineersaustralia.org.au/risk2023*
RISK 2023 will feature an exciting line-up of expert speakers exploring "Risk engineering for a resilient 2030". Join your colleagues from a wide range of engineering professions and disciplines practising engineering-related risk management, risk analysis and risk-based decision-making.
Register now

11-13 OCT 2023
SEVENTH WORLD ENGINEERS CONVENTION

Location: in-person *Prague, Czech Republic*
Website: *wec2023.com*
The global engineering community will reunite to explore the breakthrough technologies and capacity development focused on the United Nations Sustainable Development Goals.
Register now

07-09 NOV 2023
IMC INTERNATIONAL MARITIME CONFERENCE

Location: in-person *Sydney*
Website: *indopacificexpo.com.au/IMC2023*
Conference delegates will be involved in discussions concerning the latest developments in naval architecture, marine engineering and maritime technology in the areas of defence and commercial shipping.
Register now

12-15 NOV 2023
HYDROLOGY AND WATER RESOURCES SYMPOSIUM 2023

Location: in-person *Sydney*
Website: *engineersaustralia.org.au/hwrs2023*
Innovation, collaboration and engineering excellence come together for HWRS 2023, with this year's theme "Living with extremes". Topics cover the spectrum of engineering hydrology and the progress made in understanding the uncertainties facing water resources managers now and in coming decades.
Early-bird registrations close 15 September 2023

07-09 FEB 2024
11TH AUSTRALASIAN CONGRESS ON APPLIED MECHANICS (ACAM 2024)

Location: in-person *Brisbane*
Website: *engineersaustralia.org.au/acam2024*
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Abstracts close 11 August 2023

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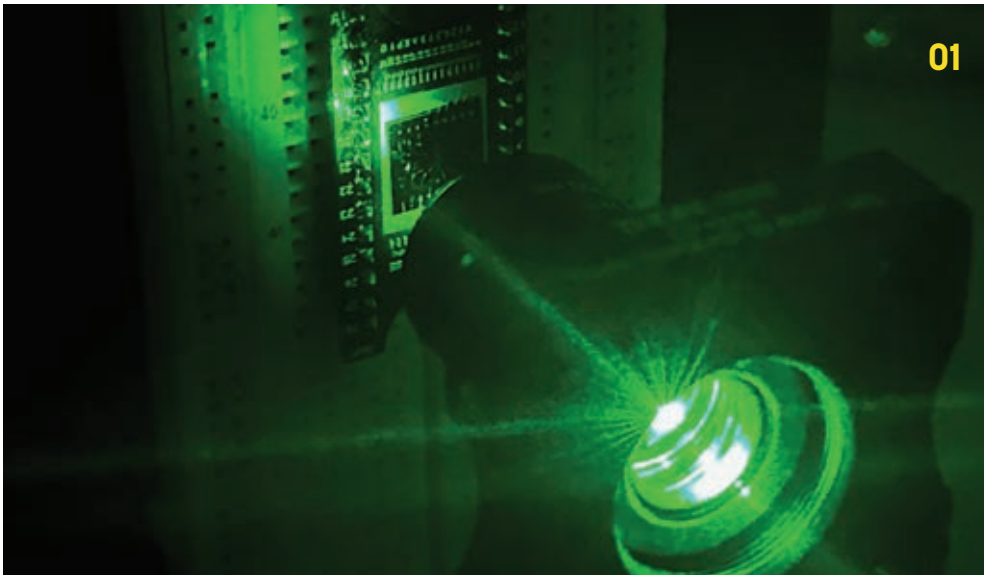
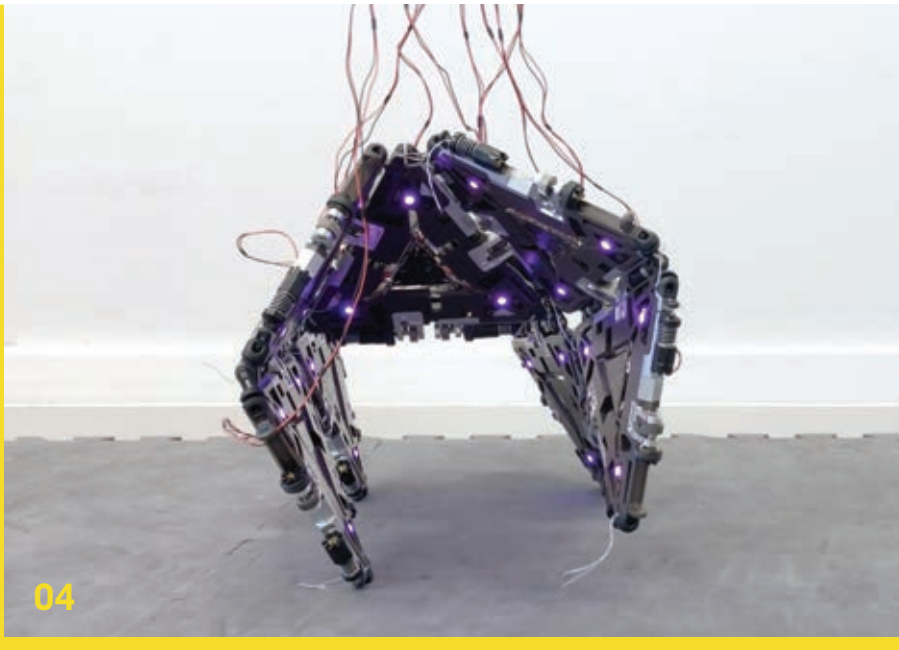
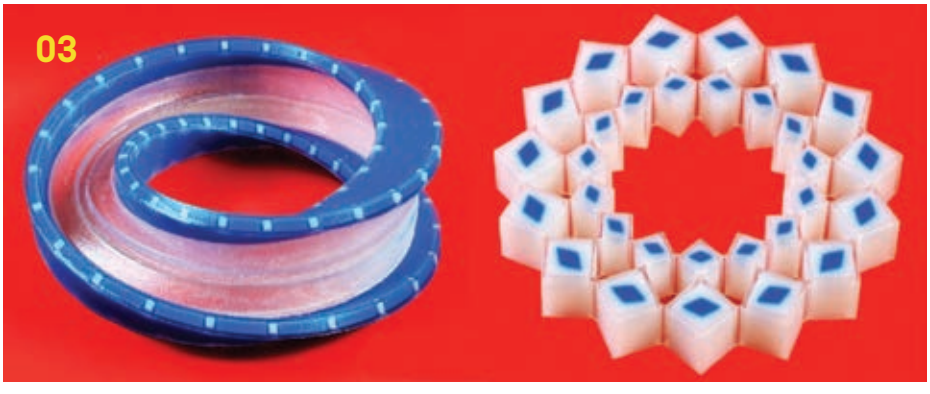






01

Neuromorphic chip

A visible light experiment is used to demonstrate the chip's capabilities. Image: RMIT University

A chip developed by a team at RMIT University mimics human vision to capture visual information and classify it in a memory system. Made from doped indium oxide, the technology is thousands of times thinner than a human hair and can process information without having to rely on external computation. Such neuromorphic vision systems, which can adapt to new situations as they are presented, are superior to traditional systems that struggle to adjust to unexpected circumstances. "Performing all of these functions on one small device had proven to be a big challenge until now," said Professor Sumeet Walia. "We've made real-time decision making a possibility with our invention, because it doesn't need to process large amounts of irrelevant data and it's not being slowed down by data transfer to separate processors." The team anticipates its device finding use in self-driving cars or for detecting space junk and operating in environments hostile to human workers.

02

High-speed data

This tiny chip transmits large quantities of data at high speeds. Image: Lightwave Research Laboratory/Columbia Engineering

A tiny chip developed by engineers at the US's Columbia University is capable of transmitting data with incredible speed and efficiency, potentially breaking the "bandwidth bottleneck" that limits the transfer of data between nodes in high-performance computers. The integrated photonic chip uses a technique called wavelength-division multiplexing to send independent streams of data simultaneously using hundreds of distinct wavelengths of light generated by a single laser. While the system transfers more data, it does not use proportionally more energy. "We recognised that these devices make ideal sources for optical communications, where one can encode independent information channels on each colour of light and propagate them over a single optical fibre," said Professor Keren Bergman. "What this work shows is a viable path towards both dramatically reducing the system energy consumption while simultaneously increasing the computing power by orders of magnitude."

03

"Frustrated" metamaterials

The "frustrated" structure of these non-orientable structures endows them with mechanical memory. Image: UvA

A new type of metamaterial developed by the University of Amsterdam and France's ENS de Lyon uses a "frustrated" design to form objects that retain mechanical memory. The researchers structured the materials as non-orientable objects that always have a point that does not deform under pressure, such as a ring of hinged squares that rotate in opposite directions. Changing the position at which the object's zero deformation point ends up permits the object to store information and even act as a mechanical computer. "These materials naturally want to be ordered, but something in their structure forbids the order to span the whole system and forces the ordered pattern to vanish at one point or line in space," said Corentin Coulais of the University of Amsterdam. "There is no way to get rid of that vanishing point without cutting the structure, so it has to be there no matter what."

04

Shapeshifting robot

Consisting of reconfigurable triangles, Mori3 can be used for a variety of tasks. Image: © 2023 Christoph Belke, EPFL RRL

A team at Swiss university EPFL has developed a modular robot that consists of two-dimensional polygons that can be reconfigured into different shapes and sizes to achieve different tasks. Named Mori3 — for Modular Origami Robot — the robot is constructed from triangles of different sizes that communicate and link up with one another. "We have shown that polygon meshing is a viable robotic strategy," said post-doctoral researcher Dr Christoph Belke. "These robots can change their own shape, attach to each other, communicate, and reconfigure to form functional and articulated structures." The robot has demonstrated its ability to move around, handle and transport objects, and interact with users. The team hopes it can be used for communication and repairs in spacecraft, but also sees potential applications on Earth for purposes such as helping people with limited mobility.

Jane Brunton

CPEng, Manager, Strategy and Optimisation, BHP

FOR MINING ENGINEER JANE BRUNTON, THE BENEFITS OF BECOMING CHARTERED WERE CLEAR EVEN BEFORE SHE ACHIEVED THE QUALIFICATION.

AS A young engineer Jane Brunton, working at a small mining operation without a strong framework for on-the-job education, sometimes found that she struggled with professional development.

That's when a senior colleague suggested she look at becoming a Chartered engineer.

"He brought up Chartered engineer status and used that framework as a learning tool in terms of guiding me on the experience that I [would] need to obtain," she recalled.

"So I looked into it, and very soon found that to achieve Chartered status, these are the things that I needed to be able to demonstrate."

From there, she was able to identify what areas she already had experience in, and also where she would need to develop her abilities — in project management for instance.

"I used the framework to guide my professional development conversation with my managers," Brunton said.

"I approached my manager at the time to say, 'Hey, I need this to be able to get to Chartered status. Is there a small project that I can manage end-to-end?'"

Today, Brunton manages a number of projects in her strategy and optimisation position at BHP. It is a role that allows her to combine her engineering expertise with her business mind, applying both to the company's development of mining sites.

"My role in those projects is about framing that business case and guiding the team in the thinking that will ultimately lead to either [moving] to the next study phase or [moving into execution," she said.

"I'm not a technical expert in the plant design of a project ... and I'm certainly not an expert in open-pit mining or major construction projects per se, but it is about bringing that holistic thinking to ask, 'Why is this project important for the company at a time? What's the context?'"

She sees herself as having to balance the engineer's desire for technical perfection with the limits imposed by a project's financial considerations.

"You might have, on paper, a really great technical solution, but in-context it might not make as much sense," she said.

"And this context requires an understanding of the business side of things to have a full picture, because you're no longer just chasing technical excellence.

"Sometimes you might have to deliberately give way on a bit of technical excellence just so that there is actually a project to keep going." ●

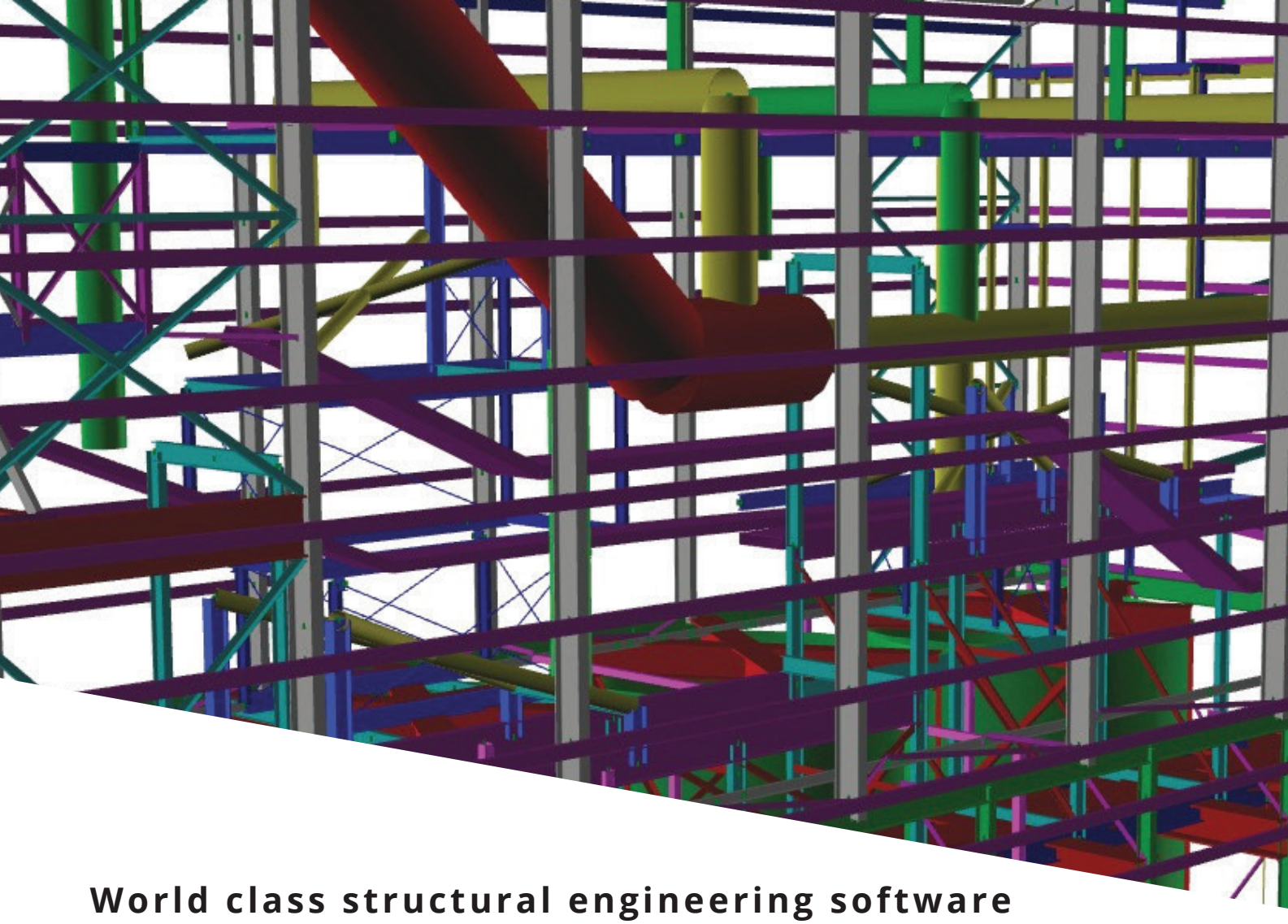
03 TIPS FOR SUCCESS

1 Sometimes it's better to pursue excellence on an existing project than to design something perfect that will never actually exist.

2 Take calculated risks.

3 If you want to achieve Chartered status, do not procrastinate.

IMAGE: BEN LIEW



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