Fulton Hogan

INNO2VATION

A year of challenge and innovation

Last year, our Innovation Report was subtitled 25 ways we're engineering solutions for the future.

A year later, I'm proud to say we are reporting on more than double this number. Ranging from 'game changing' to 'fine-tuning', they each, in their own way, help prepare us, our customers and communities for a rapidly changing future. While no means an exhaustive list of Fulton Hogan innovations in 2020, their breadth and depth gives a powerful insight into our business.

Many of these innovations come from common-sense, day-to-day problem solving, some have come from specific innovation programmes, such as Site of the Future®, and others are driven by our customers, such as incorporating greater use of recycled materials in asphalt.

Many of the changes these innovations address are part of how we constantly look to improve our business. Others address 'bumps in the road' – unforeseen developments, with often major implications. There are several examples of these within Innovation 2020, perhaps most notably our response to the Auckland Harbour Bridge disabling in October.

Whatever the problem or need, at Fulton Hogan, our purpose is to help foster more prosperous, better connected communities through safe and efficient infrastructure.

It's great to see the considerable contribution to the content this year from our valued customers and partners. At Fulton Hogan, we love nothing more than solving problems, and your input is vital in achieving this.

Finally, no report that covers 2020 can be complete without mentioning the global Covid-19 pandemic, which in itself, has forced lasting change to how we all go about our business. The fact that, in such a disrupted year, we should be able to report such a high level of innovation says so much about our talented people and the ongoing support of our stakeholders.

Cos Bruyn
Fulton Hogan Managing Director

Innovation in:

> **Innovation means different things to different people, but you can't mistake its results when you see them.**

These are the words of Waka Kotahi NZ Transport Agency (Waka Kotahi) Senior Manager Systems Management Wayne Oldfield. Seven years after the Network Outcomes Contract (NOC) system was introduced, Wayne is leading a programme on behalf of the maintenance industry to review and improve key outcomes of the NOCs, covering people, systems, safety, collaboration, sustainability and innovation. Of the six categories, the most challenging to measure and to incentivise is probably innovation.

Innovation in Network Outcomes Contract management

Developing and sharing innovation between Network Outcomes Contracts

In 2013, Waka Kotahi introduced NOCs to increase value-for-money, sustainability, national consistency, competitiveness and transparency in the maintenance of the state highway network.

Each NOC is responsible for a region's network and asset management, plus physical works (maintenance and renewals of sealed pavement and other assets), and other network-specific maintenance activities as required.

In managing seven of the 21 NOCs, and being part of the Auckland System Management Alliance (ASM), a key consideration for Fulton Hogan, and for Waka Kotahi, is how best to protect, and to share, innovations.

There are twin challenges in measuring, and rewarding, innovation among NOCs. The first is measuring the real-life outcomes of product and service innovations. The second is protecting the IP generated by the innovator while ensuring the benefits find their way to other NOCs.

"In the past, you could say we've been measuring the wrong things for the right reasons," says Waka Kotahi Senior Manager System Management Wayne Oldfield.

"As a small nation with a relatively small number of providers, we need competition to drive innovation and, ultimately, for NOC managers to share best practice."

Wayne Oldfield says innovation is a major motivator for companies. The question he poses is at what point does innovation "flick from an individual benefit to the benefit of the sector more widely?"

"At the moment we're only seeing some innovation (being shared) because, understandably, companies are keeping the best innovations to themselves. If we want to be world class, we need to innovate together."

His response has been to form an innovation group, with representatives from across providers. It has four goals:

- Agreeing on what good innovation looks like.
- Creating a framework for NOC contractors to access funds for innovation for companies of all sizes.
- Creating frameworks to share innovations.
- Instituting changes to the NOC model that encourage innovation.

Wayne says the response to these goals has been encouraging.

"When we're together, I get no real sense of who's working for who. I see a group of people who are passionate about innovation," says Wayne.

"Yet they all understand the need to be clear about what is IP, and what isn't. We know we need to build safeguards so great ideas can both be protected and shared."

Wayne says when he's measuring value for money, a large part of the 'value' side of the equation is innovation. "Value and innovation are closely related. Get those right, and the money tends to look after itself."

"I agree with Wayne, that innovation is normally intrinsically linked to value," says Fulton Hogan General Manager Engineering Solutions, Bevan Sandison. "I'm extremely proud our numerous innovations and value for money initiatives, signed off by Waka Kotahi, have been a key enabler to our six NOCs getting awarded the top six spots in the country in 2020. There is clearly a financial cost and a firm commitment required from a company to pursue innovation to lift performance. It will always be a desire to protect intellectual property to some degree, but if we get too focussed on looking over our shoulder in an attempt to protect things, we can easily lose focus on chasing down that next game-changing great idea".

Waka Kotahi Central Otago NOC Manager Mark Stewart as been overseeing 2019's top performing NOC. Mark says he's proud of the innovation driven by the team, making no apology for a high ranking being "the reason I go to work every day".

"I understand the importance of innovation and ideas if we are to remain top performing. Every time (Fulton Hogan's Central Otago NOC manager) Kieron Ingram and I address the troops, we're talking about, and encouraging, ideas."

However, Mark says there's a world of difference between great, good and indifferent ideas.

"From a scoring point of view, it can be a matter of opinion as to whether something's innovative or not, and we also don't want to stifle innovative thinking."

Mark also supports measuring innovation based on outcomes. He cites a recent spate of four accidents around the network due to sunstrike during winter months, on typically uphill gradients facing north to north-west.

The Central Otago NOC is trialling "Sun Strike Area – SLOW DOWN" signs, 150m before each of thevhigh risk locations.

"As sun strike is seasonal, we've designed the signs to fold closed during the times of the year when there is no risk, ensuring messaging is only up when relevant," says Mark.

"Solve the issue of sunstrike
– and you really have an outcome."

The site is remote – more than four hours south-west of Brisbane and a day's travel from Sydney. But despite this, the project is breaking the norm and creating new pathways for inclusion in the workforce through its Indigenous engagement and employment programs.

Site engineer Renita Androse, changing over a dust monitoring jar and recording end of month data.

Innovation in diversity

A force for change in the Outback

Located just a stone's throw from the Queensland border in the remote north-western reaches of New South Wales (NSW), the Newell Highway Upgrade – Mungle Back Creek to Boggabilla team is delivering a 28km upgrade of this nationally significant freight route connecting Queensland to Victoria through inland NSW.

The cotton town of Goondiwindi, which sits just north of the Queensland border, boasts rambling Queenslander timber houses and an eye-catching art deco main street. It was established as an official border crossing of the McIntyre River more than a hundred years ago. Over the river, 10km to the south, the small village of Boggabilla is vastly different in character to their neighbours up the road, and has a high unemployment rate. An Indigenous mission established in the early 20th century survives today, and many in the Indigenous community have remained living there for generations because of deep cultural connection to the area.

It's here in these remote communities that Brooke Emmett, project manager has established one of the most diverse teams of people on any Roads and Maritime Services project.

Up to 115 staff and contractors, including many locals, are now employed on the project, which has led to opportunities for training and employment for the region, including Indigenous people, and supplier opportunities for the wider community.

"In today's world, construction projects are more than just descending on a town to build a road, bridge, airstrip or dam," says Brooke.

"It's important we employ local workers and buy locally to support regional communities, particularly as they stare down challenges like drought and now the economic downturn associated with the Covid-19 pandemic," she says.

Under her leadership, 50% of site leadership positions are held by women, and nearly 50 people in the workforce identify as Indigenous Australians, representing nearly 20% of the total project hours worked. In comparison, most construction projects, of this size struggle to reach more than six percent of Indigenous team members.

From the outset, Brooke and her team looked for innovative ways to engage local Indigenous workers and provide upskilling to those keen on joining the project. This included rolling out a school-based traineeship for two female Indigenous Year 11 students, and embedding into the community by supporting events such as NAIDOC Day celebrations at Boggabilla Central School and Toomelah Public School, a North Star Show Jumping Event and Goondiwindi Kindergarten. The team also regularly cooks breakfast barbeques for students and staff at local schools.

Cultural Heritage Advisor Carl McGrady has also joined the project team, and there has been regular engagement with local land services, including site visits by the travelling stock reserve ranger and representatives of Moree Plains Shire Council and Goondiwindi Regional Council.

To support greater cultural understanding within the team, Brooke initiated cross-cultural awareness for non-Indigenous staff through community connections.

"Carl is a respected local Indigenous leader and has been instrumental in leading field workshops and educational talks on culture to help our project team understand the local Indigenous history and cultural differences, says Brooke.

"He also assisted the team by identifying bush tucker and medicines used in the Boggabilla Central School bush food garden, which the team helped design and create," she says.

The bush food garden concept was envisaged by the team after hearing that locals previously collected native and culturally important plants from scrubland within the project footprint.

The bush food garden at Boggabilla Central School contains native seeds and culturally important plants from within the project's corridor. It is also an education space for students and the community, with an outdoor learning and cooking area. Plans are also underway for school children to design and create Aboriginal artwork within the garden. The team unveiled the bush food garden as part of NAIDOC Week celebrations in November 2020.

The success of Brooke and her team in this unique part of Australia has set a new standard for increasing Aboriginal and female participation in construction, with the project now a blueprint for future projects.

Brooke and her team are a force for change in the construction industry, and have helped bring to life Fulton Hogan's commitment to building a diverse and inclusive workforce.

In 2019, Brooke was awarded the project manager award at the National Association for Women in Construction, NSW, Awards for Excellence. She is also a finalist for the Australian Construction Awards, women in construction award, with the project also recognised as a finalist in the diversity and inclusion award category.

Innovation in reporting

New financial functionality for Archimedes®

Of the many assets Fulton Hogan manages throughout New Zealand and Australia, roading is the largest category. It's also one of the biggest ticket items for any government. That's why Fulton Hogan's development of real-time budgetary information on its proprietary Archimedes® road asset management system is a key development.

It means clients and the Fulton Hogan teams know the exact time and cost on any project or programme at any time. The result is more visibility, transparency and timely decision-making, with no surprises. Given that asset management's lifeblood is good, timely information flows, clients need relevant information on the assets at all times.

"We wanted to get away from monthly reports, for better conversations based on immediate financial information that's available to everyone on the contracting team," says Information Systems Manager, Road Maintenance, Danny Fitzgerald.

"Using data-based decision making helps make every decision as informed as possible."

It's perhaps instructive that Archimedes® monitors are placed in Fulton Hogan's canteens, where they are visible and top-of-mind.

"If you put the information where the kettle is, by the time the kettle has boiled you'll probably have learned something new."

Archimedes® is Fulton Hogan's proprietary business intelligence and analytics platform for tracking and analysing the various parts of the road maintenance contracts. The dashboards, which update hourly, cover categories including:

- Real time costs incurred on any project.
- Monthly programme achievement (contract-specific).
- Monthly programme achievement (nationally).
- Pavement and surfacing renewals (contract-specific).
- Pavement and surfacing renewals (nationally).
- Customer service/public requests (contract-specific).
- Culvert inspections (contract-specific).
- Culvert inspections (nationally).
- OPM – overall performance measures – (contract-specific).
- OPM – overall performance measures – (nationally).
- Event manager – monitoring remediation following a major event such as major storm.

Clients can check in on any of the above, at any time, from any location, and contact Fulton Hogan about any aspect as needed. Any public requests, comments or complaints are also logged.

"These assets belong to our clients and, ultimately, to the public," says Danny. "It's vital, therefore, that local and central government authorities can track maintenance performance, and that we record the public's feedback on their behalf."

Innovation in road maintenance

Unique road closure programme improves travel and safety

In Te Reo, 'Remutaka' means 'sitting down to rest'. It's perhaps an ironic name for the Capital Journeys® team, who maintain the vital arterial link over the Remutaka Hill.

Their maintenance and slip prevention work is concentrated into three intensive blocks of five-night closures and four Sunday night closures per year, part of an innovative approach to maximising safety for the team and road users on the arterial route between Wellington and Wairarapa,

Capital Journeys® – a Waka Kotahi/Fulton Hogan/WSP joint venture – is the first NOC in New Zealand with a schedule of maintenance closures for a key arterial route.

This stems from human-centred design work using Fulton Hogan's SCiD²® (Safety & Customer in Design & Delivery) methodology, considering engineering solutions from end users' perspectives early in the planning process.

> **"Ultimately, it's about customer care – a better result for customers through good planning and good communications.**
>
> Waka Kotahi Manager System Management (Wellington) Mark Owen.

The 13km Remutaka Hill road is the only route across the mountain range between Wairarapa and Wellington. It's critical for the Wairarapa community's access to Wellington hospitals and a key route for freight, particularly logging, to the Port of Wellington. At least 6,500 vehicles, many of them commuters, use the hill road daily, and the only alternative is by train (tunnel) or an additional 100km by road via SH1.

The stop/go works that previously disrupted travellers around 300 times a year have been reduced by 95%, and productivity significantly increased by doing a year's worth of work in 23 brief road closures.

Waka Kotahi Manager System Management (Wellington) Mark Owen says the key is a combination of advance warnings for the public and businesses, and ensuring access for those with a 24/7 travel need.

"The greatest consideration is safety, given the steep, winding and often wet and windswept road. Ultimately, it's about customer care – a better result for customers through good planning and good communications," says Mark.

He describes this as a win-win because the Capital Journeys® team can focus on exactly what they need to do, when they need to do it.

"It's a chance to plan activity in detail, and to have more options for multiple work sites. To get in there and hit it hard."

Capital Journeys® Community Relations Manager Lynsey Morgan says the alternative 100km route up SH1 made the closure proposal a challenging sell, at least initially.

"Even though it was compelling to address road worker and driver safety that was being compromised by almost daily stop/go maintenance operations, this wasn't universally accepted at first."

Meetings with trucking umbrella organisations, Wairarapa logging industry representatives, district councils, chambers of commerce, police and the Wairarapa District Health Board helped the team understand concerns about the closures in detail.

The trucking industry was the biggest concern. Additional consultation led to a new schedule of closures when less wood was transported, along with some adapting of work practices by trucking firms around the closures.

For the public, an intensive awareness campaign began six weeks before the first closure to encourage people to organise their journeys around closures, and to encourage those adversely affected to make contact for assistance.

"From a vocal contingent of early complaints aired in the media, our online survey shows the closures now have general public support, and local media stories about the closures are now consistently positive," says Lynsey.

The team also works with Wellington Airport, ferry companies, tourism operators and concert promoters to publicise the closures to their customers through their channels.

Fulton Hogan Wellington Regional Manager Daren Courtnage says the success of the road closure strategy on the Remutaka Hill suggests the approach could be valuable elsewhere in New Zealand.

"I think it's fair to say the early stakeholder engagement, driven through our SCiD²® process, has ensured a positive public response and strong performance by the team on the hill," says Daren.

"The Remutaka Hill has some unique characteristics, but it's certainly not the only stretch of road where driver and worker safety, traffic flows, project efficiency and product quality could be improved by thinking about road maintenance in this way."

Innovation in inspections

Digital interface revolutionises potholing

Potholing is a vital step in checking if, and exactly where, utilities lie underground.

Although councils have records of subterranean utilities, these do not necessarily capture all new and existing alignments and depths, particularly when the pipes were laid a long time ago. Seismic and other underground movement, particularly relevant to Christchurch, can also affect alignments.

Major road renovations in Victoria and Hereford Streets on behalf of the Christchurch City Council (CCC) in 2020 were an opportunity to revisit the time-intensive traditional approach to potholing, and to look to improve accuracy at the same time. It was also an opportunity to harness advances in digital engineering and technology in the civil infrastructure field.

Working with partner Abley Consultants, the goal was to create a digital interface for the Trimble-based system to remove manual spreadsheet recording attributes, cross-section sketches, paperwork and manual rendering by way of a digital interface for 3D modelling of subterranean utilities.

The result is a considerable saving in time in back-end office processing to provide deliverables that consistently meet local authorities' coding and layering requirements, along with supplementary PDF files, rich with attributes to support the 3D data.

Fulton Hogan's Hayden Gibbons says these gains are not only immediate, but they will be valuable over time because of the benefits digital archiving brings.

"The results have already exceeded expectations," says Hayden. "With up to an hour saved per pothole log sheet, the cost benefit adds up very quickly, especially on the bigger pothole investigation packages."

Abley Consultants' Matthew Noon says the goal was a data schema built around a drop-down list to define type, colour and owner of utility services, thereby reducing potential for human error and the amount of previous 'free capture' of information that was distorting results. The result is spatially-referenced digital twins plotted on a digital interface that can be reviewed in near to real time.

"The Trimble system itself is fine – the opportunity was to process and output the data more effectively. The digital interface could also be used with Leica or other systems in future," says Matthew.

Hayden says that from an operator's perspective, the new approach means slightly more time in the field to allocate the correct attributes to the data from drop down lists, to ensure exactly the right information pulls through to deliverable automation. However, the time saved on the back end far outweighs this, he says.

Fulton Hogan and Abley Consultants initiated a partnership at the start of 2020 to grow and develop Fulton Hogan's digital engineering capability. Abley Consultants is a specialist transport planning and engineering, location and technology consultancy, with a particular focus on how process improvements can improve outcomes, reducing cost and time. "Fulton Hogan and Abley Consultants have a similar ethos for excellence, which stems from our roots. We're both New Zealand owned and operated, we're innovative and work hard to create a better New Zealand" says Steve Abley, chief executive at Abley Consultants.

With up to an hour saved per pothole log sheet, the cost benefit adds up very quickly, especially on the bigger pothole investigation packages.

Survey Department Manager
Hayden Gibbons.

Innovation in energy

Powering up renewable energy deal

Fulton Hogan has joined several prominent Melbourne businesses and universities in securing a multi-million-dollar deal to power our Victorian operations using renewable wind energy.

The second Melbourne Renewable Energy Project (MREP2) purchasing group of seven large energy users includes Fulton Hogan, Citywide Asphalt Group (a Citywide and Fulton Hogan joint venture), RMIT University, Deakin University, Cbus Property, ISPT and Mondelez International.

The new MREP2 deal means 14 shopping centres, nine office buildings, seven educational campuses, and manufacturing facilities, including five Fulton Hogan asphalt and blending facilities and quarries at Tylden and Tynong, will be powered by renewable wind energy. It will result in a reduction of greenhouse gas pollution by 123,000 tonne a year, the equivalent of taking more than 28,000 cars off the road annually.

"This project will enable Fulton Hogan to power all of our quarries, asphalt plants and blending facilities across Victoria with renewable, carbon neutral electricity," says Chief Executive Officer Infrastructure Services Matthew MacMahon.

"More than 7,000 tonne of carbon will be removed from the environmental footprint of the products we manufacture, and the roads and infrastructure we build across the state."

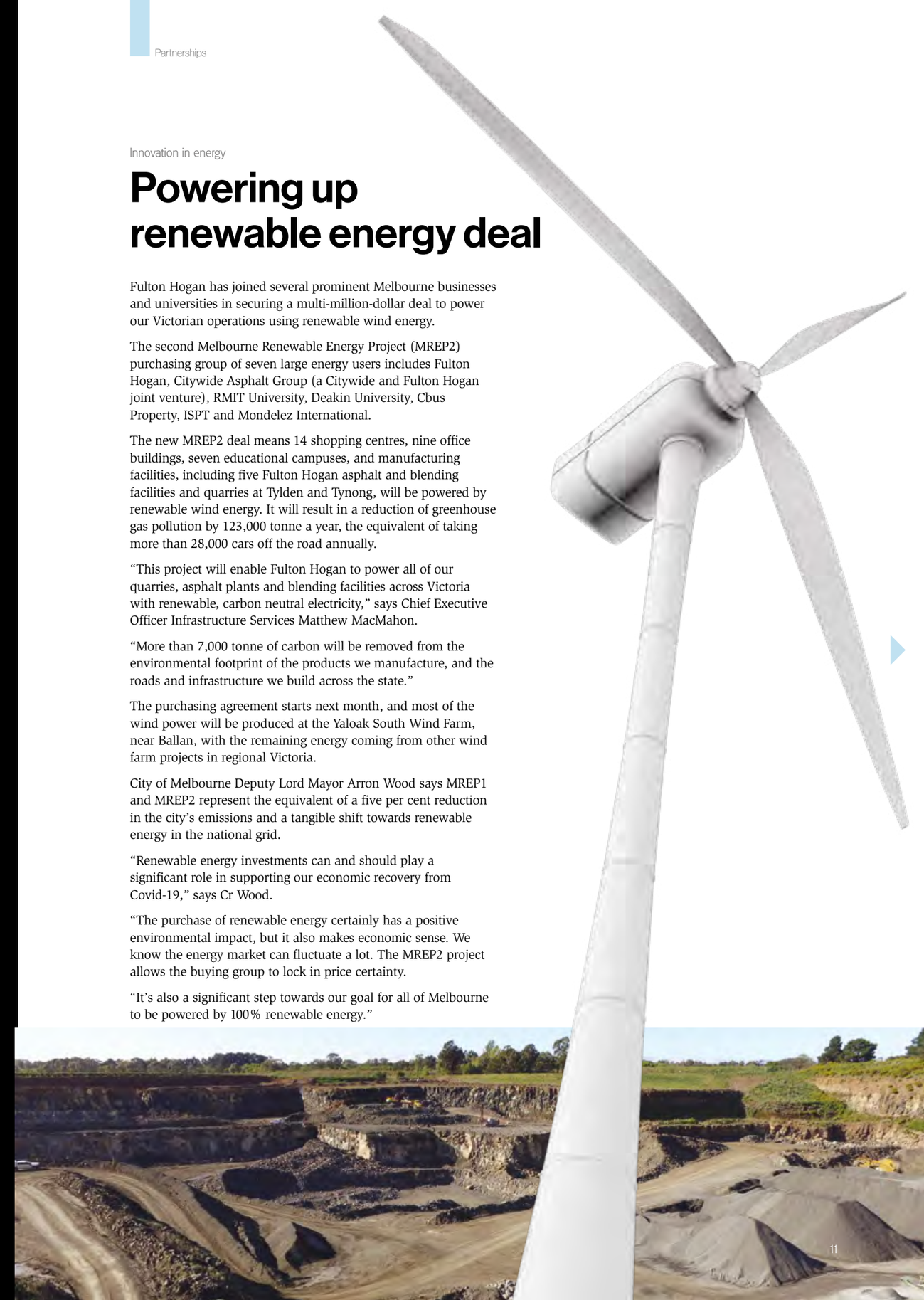
The purchasing agreement starts next month, and most of the wind power will be produced at the Yaloak South Wind Farm, near Ballan, with the remaining energy coming from other wind farm projects in regional Victoria.

City of Melbourne Deputy Lord Mayor Arron Wood says MREP1 and MREP2 represent the equivalent of a five per cent reduction in the city's emissions and a tangible shift towards renewable energy in the national grid.

"Renewable energy investments can and should play a significant role in supporting our economic recovery from Covid-19," says Cr Wood.

"The purchase of renewable energy certainly has a positive environmental impact, but it also makes economic sense. We know the energy market can fluctuate a lot. The MREP2 project allows the buying group to lock in price certainty.

"It's also a significant step towards our goal for all of Melbourne to be powered by 100% renewable energy."



Innovation in project structuring

Northern Corridor Improvement's hybrid alliance model in action

The Northern Corridor Improvements project (NCI) is New Zealand's first 'accelerated hybrid alliance' model run by Waka Kotahi. The second – the Te Ahu a Turanga: Tararua Highway – commenced this year. This new model reflects a trend towards structuring projects for flexibility and greater clarity on project risks, with increased collaboration, efficiency, innovation and safety. Here, Waka Kotahi's Simon Paton and Andrew Thackwray give an insight into the hybrid alliance difference on the NCI project.

First of all, a definition. A 'pure alliance' is chosen on 'team and attributes', after which the project scope and price are developed and agreed.

A 'competitive alliance', by contrast, is chosen on 'price and attributes'. Although this creates tension around price when submitting, it can create a risk of some contractors submitting prices they cannot deliver on, with inventive interpretation of minimum requirements.

An 'accelerated hybrid alliance model' focusses on delivering the greatest value under an established affordability threshold. This gives the owner greater flexibility to select the outcomes that are important to them within the budget set.

This approach, used for the first time on the NCI project, has allowed the project to make up 98 days lost to Covid-19, deliver $240 million of additional elements post commencement, and the complexity of three community projects.

The NCI alliance – Waka Kotahi/Fulton Hogan/HEB/WSP/Jacobs – is delivering improved motorway connections on Auckland's North Shore between SH1 and SH18, opening up the Western Ring Route, extending the Northern Busway to Albany, and providing walking and cycling paths to improve community connections and transport options. Its complexity includes the need for three significant community amenities within the project, and 400 people working on as many as 50 work sites simultaneously.

From Waka Kotahi's perspective, its scale is just one of the operating challenges. Consider:

- The tender was awarded in July 2017, prior to all land being purchased.
- The project involved building three diverse community amenities - the $75 million National Hockey Centre, the Wainoni Park Pony Club equestrian hub, and the North Harbour BMX facility – each with quite different design needs and parameters to typical horizontal infrastructure.
- The contractual flexibility necessary to add $240 million of additional work to the original $450 million scope, without compromising the core project.

"We needed a different procurement process and a different conversation with tenderers," says Waka Kotahi Principal Project Manager Simon Paton.

"We needed to maximise focus on KPIs and the collaborative behaviour necessary to achieve them, while saying 'we have $447.4 million, tell us what you can do with that and don't spend a dollar more'.

"People can propose all sorts of things, including amazing urban design, but what was most important was defining and communicating exactly what the Waka Kotahi most valued. That led to some interesting conversations," says Simon.

With unknowns in the project, and the need to integrate new sporting facilities, it was decided to put all tendering entirely within the alliance scope.

"We knew, for example, that any hold-up on the hockey centre would slow the work more generally. Rather than go to a separate tendering process (for each element), the most direct and quickest way was to negotiate all the scope at once," says Simon.

"This created the necessary healthy tensions, flexibility and teamwork because the parties were all in it together."

A team mantra was the customer at the heart of all decision making. Practical outcomes of this included just four major changes to traffic lanes on SH1 over the four years of the project, reducing driver confusion, frustration and accidents during the work. Simon highlights the work of founding Project Director Andrew Johnson (Fulton Hogan) and alliance board members Peter Spies, Derrick Adams and chairman Mike Howat (Fulton Hogan) in translating the tender's intent to reality.

"This is my third alliance with Mike Howat as board chairman, and the board has worked together on so many projects that they bring invaluable experience, knowledge and relationships."

Waka Kotahi Senior Manager Project Delivery Andrew Thackwray says the relationship between the teams and the governance group has been essential in reducing the effect of delays to the project.

"We are still looking at how we can consolidate our work programme even further, with a new work programme to make up for lost time to get the project finished as quickly as possible," says Andrew.

"This is a typical part of the alliance model, where flexibility and innovation drive better outcomes in delivering big projects."

An example was the decision to plan for, and accelerate, work under Alert Level 3 to complete the new McClymonts Road Bridge over SH1. This work was originally scheduled for the Easter and school holiday break, until Alert Level 4 lockdown intervened.

"Under Alert Level 3, fast resumption of work meant taking advantage of the relative quiet on the streets and pressing ahead with the bridge with little disruption to traffic and the nearby Albany bus station. Access to the bridge was closed off as a new road surface was laid and the finishing touches added to the roundabouts at each end," says Andrew.

"It was a very good outcome. It shows the professionalism of our alliance and the commitment to completing the project to the highest standard."

Innovation in disaster recovery

Completion of repair marks a “stunning job”

For an incident affecting motorists travelling hundreds of thousands of kilometres across Auckland, the remediation was measured in millimetres. Over a weekend in early October 2020, the ASM team completed the replacement of the Auckland Harbour Bridge member that was dislodged when a 127km/h gust blew a truck into an upright strut of the over-arch.

In just 16 days from the incident, the team managed to:

- Assess damage to the bridge and design a temporary repair.
- Source materials and arrange fabrication of a temporary strut, installing this on day four to allow for two further lanes of traffic.
- Design and confirm a methodology for the permanent repair.
- Arrange fabrication, then successfully install the permanent repair comprising a 22.7m long, five tonne steel member, and re-tension the new member to bring the bridge structure back to full working order.

“Unlike the temporary fix, which was a matter of filling the gap, the modelling showed the permanent member needed to address a drop in the bridge deck. In essence, we needed to help pull the bridge back into shape, and take the pressure off dozens of other members,” says ASM Deputy Alliance Manager Dave Rendall.

Modelling showed the 22.7m member – actually two members bolted together in-situ under tension – needed to lift the bridge deck in the area by about 60mm, under 75 tonne of tension. In the end, the figures came in well within the design parameters.

The opening of the final two lanes followed peer review by UK-based structural engineers Arcadis. Freemans Fox, who designed the bridge in the 1950s, is a forebear of Arcadis.

The ASM team used 3D laser scanning, point cloud and 3D mesh, along with a 360-degree imagery walkthrough of the surrounding environment to assess the wider effects of the damage. ASM, through Beca, has detailed load models of the bridge used for analysing fatigue, load limits, and to prioritise maintenance.

In addition to safety and performance, careful attention was paid to the appearance of the new member. The team worked with a heritage advisor to ensure the new strut matched the landmark status and heritage values of the bridge.

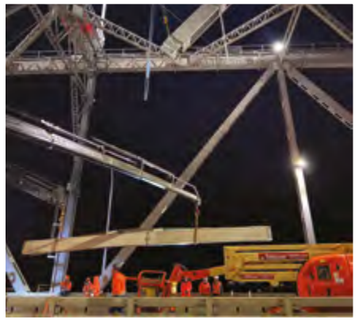
The feedback from Waka Kotahi was effusive.

> **A massive thank you to all of those people working behind the scenes to do all the traffic management planning, scenario planning, crunching the numbers and doing check after check. To the teams on the ground both on the bridge for the install, in traffic management and response teams and in the Auckland Traffic Operations Centre monitoring and managing the network – you’ve shown a commitment and passion to getting the bridge repaired that has made me incredibly proud.**
>
> Waka Kotahi General Manager Transport Services Brent Gliddon.

Dave says the experience is a reminder of the importance of seeing risk from all angles.

“While the possibility of a vehicle damaging a member was on the risk register, and there was little that could have been done otherwise in this case, it’s important to look at risk from the perspective of consequence as well as likelihood and consequence combined,” says Dave.

“It doesn’t mean we can protect against all risks, but it triggers us to have another look at how we see risk. When the dust settles, we will delve into what we learned, but in the meantime it is time to recognise a lot of people who did a stunning job in a very short space of time.”



Innovation in new technology development

Making gains through beta testing

A symbiotic relationship between Fulton Hogan Canterbury and Caterpillar Trimble Control Technologies for beta testing machine control systems is increasing the accuracy of new pavement surfacing.

With a Trimble test site at Fulton Hogan’s Miners Road quarry, near Christchurch, the relationship gives Fulton Hogan early access to the latest developments in machine control technology, while for Trimble it means a ready source of construction and surveying teams to beta test their technology.

The most recent gain from this collaboration has been improved paver laying, resulting from an insight by Survey Department Manager Hayden Gibbons. From his many hours on-site looking after machine control paving, Hayden was aware that when joint match paving against the kerb, any adjustments made on the kerb side would also occur on the free edge. This could cause undulations in the pavement.

During Hayden’s feedback session as part of the testing, it became apparent that the machine control system held the design cross-fall fixed. In doing so, when the kerb side was raised or lowered, the same level adjustments would be applied at the floating edge, meaning it could be too high or low.

Trimble has now modified the machine control system logic to ensure any minor adjustments made to match the kerb are only at that side, with the system over-riding the design grade to have the free edge ‘chase’ the design level.

This relatively simple change to the machine control logic ensures the minor adjustments necessary to match the as-built levels are not continued through the next paving runs.

Divisional Manager Richard Smith says such beta testing initiatives can have immediate benefits for Fulton Hogan and, by extension, clients.

“They will also, with time, benefit the wider industry, making them all the more worthwhile,” says Richard.

Innovation in alternative design and material selection

Luggage Point Sewage Treatment Plant

Channels Plant Settlement Mitigation Project

The Luggage Point Sewage Treatment Plant is Urban Utilities' largest and most critical sewage treatment facility. The plant serves around half the population of Brisbane, and needs to maintain stringent performance criteria for the release of effluent into the environmentally sensitive Moreton Bay.

Urban Utilities General Manager Integrated Infrastructure Delivery Services Michael Kahler says with Urban Utilities facing the financial headwinds of Covid-19, population growth and an ageing asset base, it needs more innovative design and construction practices to maintain affordable high quality services for its 1.5 million customers.

The result is their program management approach.

"The program management approach is creating a collaborative contract framework, where Urban Utilities can leverage capability and foster innovation through four delivery partners and two premarket design partners," says Michael.

"The Fulton Hogan team, with designer SMEC, has strived to seek innovative and cost-effective approaches to deliver new assets and improve outcomes for our operators and customers."

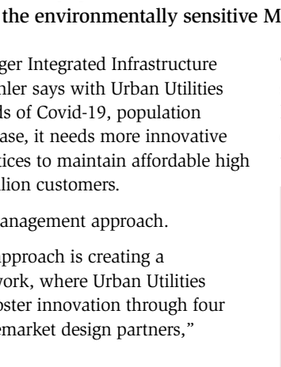
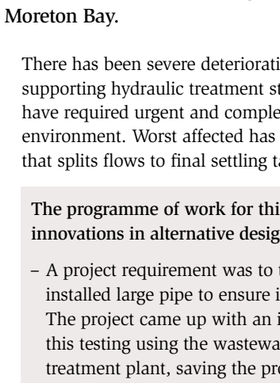
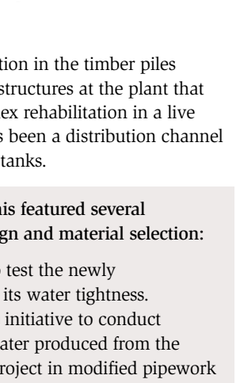
Michael says an example was identifying an alternative solution that allowed two of the Luggage Point Sewage Treatment Plant's final settling tanks to be taken offline, without affecting plant function and wastewater quality. This enabled the plant to continue operating during construction, saving more than $13 million in capital costs, and taking two years off the initial construction schedule.

The Fulton Hogan team identified the use of Xylem's 'pipe diver' system as an alternative to assessing the condition of 5.5km of a 1,295mm diameter sewer rising main. This enabled the pipes to be tested using electromagnetic technology, without needing to drain and clean the pipe, thus eliminating confined space entry risk. The approach also shortened the shutdown period from eight weeks to a single week, and avoided the risk of wet weather forcing water back into the pipe.

There has been severe deterioration in the timber piles supporting hydraulic treatment structures at the plant that have required urgent and complex rehabilitation in a live environment. Worst affected has been a distribution channel that splits flows to final settling tanks.

The programme of work for this featured several innovations in alternative design and material selection:

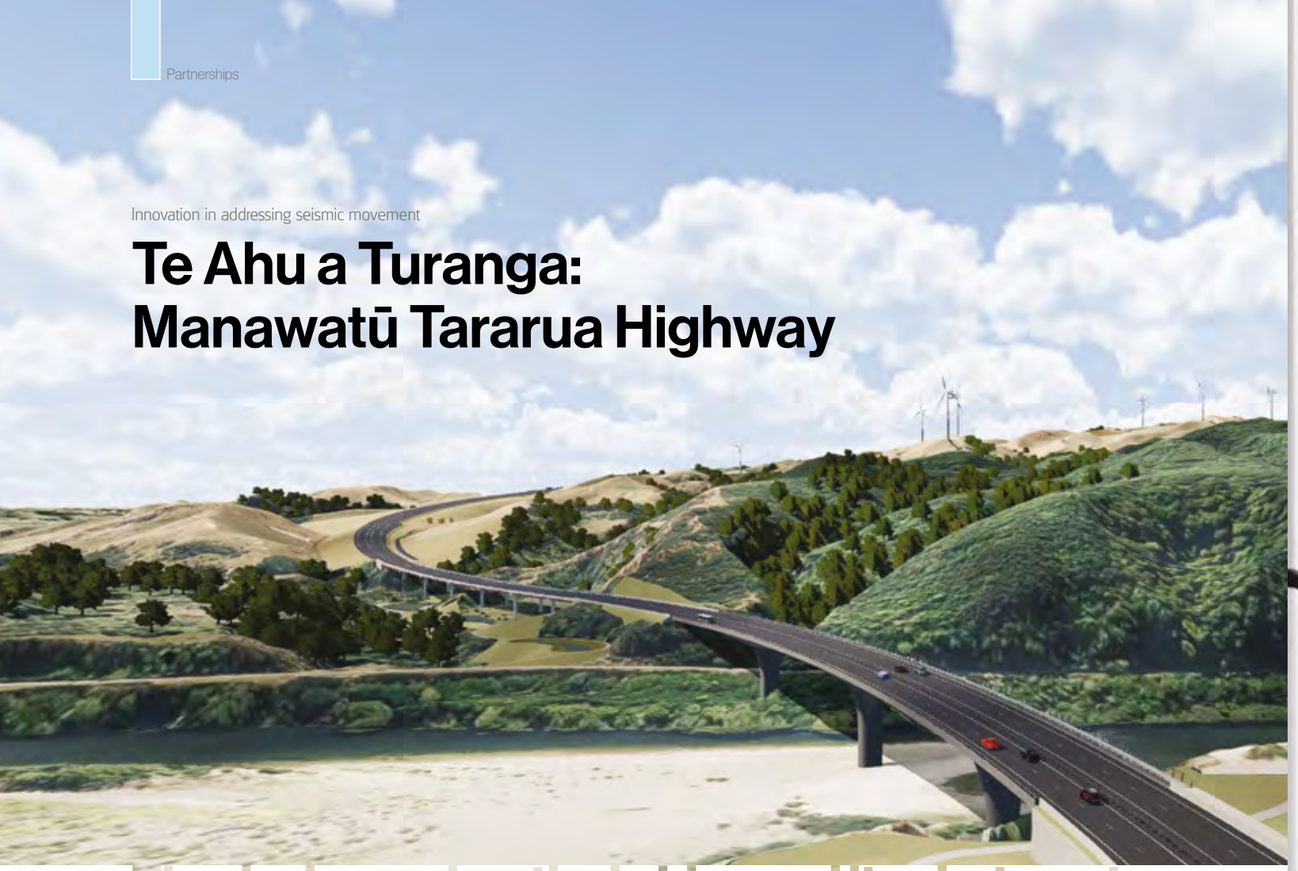
- A project requirement was to test the newly installed large pipe to ensure its water tightness. The project came up with an initiative to conduct this testing using the wastewater produced from the treatment plant, saving the project in modified pipework and in procuring various materials and equipment to conduct tests.
- The initial designs involved retaining the existing failed concrete channels, then installing foundation piles into the base of the channels to prolong the life of the channels at a significant cost. Fulton Hogan and SMEC developed an alternative design that involved new piping on piled concrete, under which the failed channels were demolished and replaced with reinforced concrete driven piles, to which new 1,200mm pipe would be supported. This change in design enabled faster and more efficient construction, along with cost savings.
- Selecting rubber ring joint pipework, rather than pipework with flanges and expansion bellows/joints, reduced costs.
- The existing underground valve pit walls were retained so these walls could be used to hold sections of the newly installed pipe in place. This eliminated the need for additional piles, and resulted in cost savings.

> "...seek(ing) innovative and cost-effective approaches to deliver new assets and improve outcomes for our operators and customers.
>
> Urban Utilities General Manager Integrated Infrastructure Delivery Services Michael Kahler.

Innovation in addressing seismic movement

Te Ahu a Turanga: Manawatū Tararua Highway



The design makes the bridge and its abutment walls easy to build and capable of coping with large seismic induced ground movement.

Fulton Hogan, HEB Construction, WSP, Aurecon and iwi are Waka Kotahi's partners on Te Ahu a Turanga: Manawatū Tararua Highway. Planning work began in 2018, and the motorway and shared path will replace the former Manawatū Gorge route (SH3) that was closed in 2017 after a series of slips. It will traverse 11.5km of hilly and seismically prone land, linking the provinces of Manawatū and Hawke's Bay.

The seismically active nature of the area was a factor in developing a stream bridge that is able to handle potential long-term fault creep movement up to one metre, and building seismic resilience into earthworks by using geotextile reinforced 'rafts'. These concepts were introduced to the project by the geotechnical team, led by Dr Ka-Ching Cheung of Gaia Engineers.

A seismic-ready bridge will cross the Mangamanaia Stream, reflecting the fact the stream runs along a potentially active fault line. As a result, a series of geotechnical design solutions are being combined that will allow the bridge to cope with ground movements of up to one metre during its design life.

The bridge will be supported by shallow pad foundations on steel strap reinforced earth abutment walls. This design gives flexibility for the foundations to move, without damaging the bridge's super structure or substructure. The design makes the bridge and its abutment walls easy to build, and capable of coping with large seismic induced ground movement. Below the flood water level, the ground is replaced by a geogrid reinforced raft with cement treated granular fill. This strengthened the erosion resistance of the bridge abutment walls against flood water.

This bridge and its abutments have been designed to deal with large fault movement. A "stress relief trench" will be built at each end of the bridge deck at the upper part of the abutment. This allows fault movement induced stress that builds up in the bridge to be easily released by excavation and redone after major seismic events. In addition, there will be wider-than-usual earthworks to allow for road realignment or correction, should there be land movement. The result is improved resilience and flexibility, allowing adjustments to be made after any significant movement, at relatively low cost.

Complementing the seismic resistant bridge is seismic resilience that will be built within earthworks with geotextile reinforced rafts. To protect drivers' safe crossing of fault lines in any abrupt fault rupture earthquake events, reinforced rafts built of layers of geotextile will be placed at locations of all known faults along the alignment.

Innovation in project recording

The measure of quality

Quality is never skin deep, or just what meets the eye.

It's in the records of what actually happened at each step of a project – the proof of a top quality job. On larger projects this requires a detailed paper trail – a mountain of digital records generated by multiple people on multiple platforms.

Just 18 months into the Auckland Manukau Eastern Transport Initiative (AMETI), Eastern Busway project (Stage 1) in Auckland, more than 25,000 documents had been generated. That's an average of around 50 new documents every working day.

To meet these demands, Fulton Hogan's Quality team introduced M-Files, a system for linking information so that everyone works with the same records, no matter what part of the project they're on, or where they're working. The key is that these records are also easy to locate and to work on from anywhere.

"We're measuring the quality of our inputs and outputs, and it makes sense to have the best quality means of doing that," says Quality Manager Felix Chong. "For our clients, quality measurement is their quality assurance."

M-Files was piloted with Auckland Transport on the project and is reducing physical document control management by around half.

"We explained to Auckland Transport that with technology changing so fast, the system would be in a constant state of development, and they were prepared to go on the journey with us," says Felix.

M-Files is now also being used with clients ranging from Watercare to Waka Kotahi and Waimea Community Dam.

Quality Engineer Rebecca Rappel says M-Files gives "lots of visibility".

"There's no need to take anyone's word that something is up-to-date, or to go looking for it – it's right there in real time.

"It's innovative and makes keeping on top of quality so much easier for the client and for Fulton Hogan."

> **"For our clients, quality measurement is their quality assurance.**
>
> Quality Manager Felix Chong.

Innovation in service integration

Wellington Water shows together is better

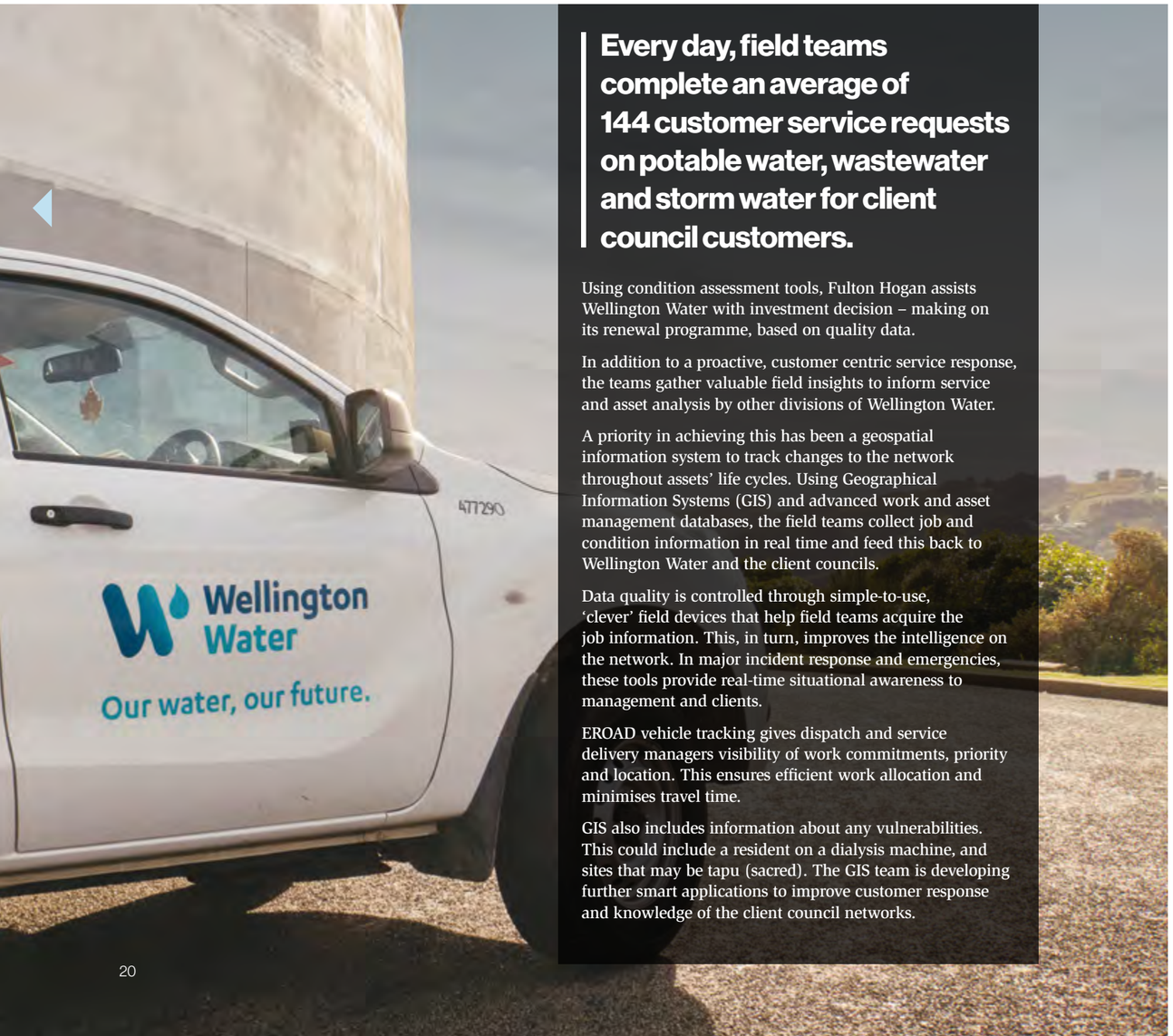
Wellington Water's core values are like a window into this collaborative enterprise. Mid-2020 marked the first anniversary of the collaborative partnership (alliance) between Fulton Hogan and Wellington Water. The goal was enhanced service delivery and customer experience, efficiency and better value for money for the six client councils.

"Wellington Water actively promotes collaborative relationships with suppliers, to help deliver key outcomes for customers and clients, to build capability across the whole team and support a holistic approach to caring for water," says Colin Crampton, chief executive of Wellington Water.

"The Fulton Hogan alliance is one example of our partnership approach, which we are seeing offers real benefits, not just for each partner but for the growth of the industry as a whole."

Key to this has been considering water management not only from the traditional engineering-based mind-set of 3 Waters, but as 'one water'.

The integrated alliance's field teams manage and carry out the operational functions for Wellington Water on the reticulation networks and support the water treatment plants, as required.



Every day, field teams complete an average of 144 customer service requests on potable water, wastewater and storm water for client council customers.

Using condition assessment tools, Fulton Hogan assists Wellington Water with investment decision – making on its renewal programme, based on quality data.

In addition to a proactive, customer centric service response, the teams gather valuable field insights to inform service and asset analysis by other divisions of Wellington Water.

A priority in achieving this has been a geospatial information system to track changes to the network throughout assets' life cycles. Using Geographical Information Systems (GIS) and advanced work and asset management databases, the field teams collect job and condition information in real time and feed this back to Wellington Water and the client councils.

Data quality is controlled through simple-to-use, 'clever' field devices that help field teams acquire the job information. This, in turn, improves the intelligence on the network. In major incident response and emergencies, these tools provide real-time situational awareness to management and clients.

EROAD vehicle tracking gives dispatch and service delivery managers visibility of work commitments, priority and location. This ensures efficient work allocation and minimises travel time.

GIS also includes information about any vulnerabilities. This could include a resident on a dialysis machine, and sites that may be tapu (sacred). The GIS team is developing further smart applications to improve customer response and knowledge of the client council networks.

Innovation in designing enterprise into an operating model

Enterprise by name, enterprising by nature

The Enterprise Model defines the relationship between Watercare Services and partners Fulton Hogan, Fletcher Construction, Beca, GHD and Stantec.

Project Director Ian Jonkers says incentivising and enshrining collaboration within the contract has built high levels of trust between partners. As a 10-year programme for the delivery of water and wastewater infrastructure for Auckland, there's also a "longer runway" to develop and advance joint initiatives, sharing innovation and quality recording through aligned IT systems.

"We're all in this together. We understand the whole programme. We share the pain and the gain, and have more direct and timely conversations."

Ian says the principles of the Enterprise Model can apply regardless of scale.

"Any project benefits from collaboration, with designers and contractors working together as early as possible to unlock maximum benefit."

He says learnings from the model with Watercare are likely to flow over into other projects.

"For example, I am sure the lower carbon concrete we've been developing will be of interest to Waka Kotahi.

"If we can make it easier for others to cross hurdles that lead to industry change, all the better."

At the heart of the Enterprise Model is 40:20:20 Build Better Infrastructure. This is the goal of a 40% reduction in carbon emissions from construction and a 20% reduction in the cost of construction, by 2024. The final '20' relates to the goal of a 20% year-on-year improvement in health, safety and wellbeing for the team.

Integrating sustainability, cost and safety is driving innovation and collaboration. The biggest correlation is between carbon emissions and efficiency, given lower emissions are often a direct result of greater efficiency. Reflecting this, a carbon measurement tool is used at the outset of a project, and the team is challenged to consider, among other things, if a 'build nothing' approach is feasible. This helps reset minds, and acts as a reminder to canvas all options in a drive for efficiencies within, and across, projects. Furthermore, no project may be started without considering its implications on any other project.

Carbon emissions, as a proxy for resource efficiency, requires new measures and processes. This includes a carbon baseline based on traditional business-as-usual practices. This is showing that the majority of carbon emitted is in the network and transmission (pipelines), as opposed to treatment infrastructure, pointing to significant opportunities for greater efficiency in construction techniques and excavation.

Two examples of efficiency gains:

1. The need for around 2.5km of pipeline has been being eliminated by adding a pump station, leading to a 70% carbon reduction, a cost saving of $5 million, and construction time saving of approximately 240 days.
2. The Hunua 1 treated water main, more than 60 years old and in poor condition, had a baseline solution of a 10km 1.575m diameter concrete-lined steel pipeline. A 40:20:20 challenge led to a second option, whereby a smaller 1.254m diameter concrete-lined steel pipeline could be built with the replacement of an existing pump station, providing a 27% reduction in carbon emissions and a similar cost saving.

"Any project benefits from collaboration, with designers and contractors working together as early as possible to unlock maximum benefit.

Project Director Ian Jonkers.

A profile in innovation

Dr Bryan Pidwerbesky

Fulton Hogan Technical Director – Pavement & Materials Engineering Bryan Pidwerbesky has spent more than 30 years helping ensure vehicles adhere to roads, through applied research and engineering practice with universities, road transport authorities and contractors.

When people think about road safety, the person who designs the surface isn't generally the first to mind. Bryan, however, works at the exact point the rubber hits the road. Literally. His working life has been about increasing skid resistance and road smoothness and, hence, driver and road worker safety.

It isn't possible to know many lives his work has saved, and how much trauma it has prevented. But many gains in road quality and safety in Australasia over the past three decades can be traced back to the name Bryan Pidwerbesky.

The son of a highway maintenance manager, Bryan wanted to be a road engineer from the age of 10. With a Bachelor of Science in Civil Engineering and a Masters in Science in Transportation and Geotechnical Engineering from the University of Saskatchewan (in Canada), Bryan came to Christchurch in 1986 as a lecturer in pavement engineering at the University of Canterbury. There he completed his PhD in Civil Engineering on the fundamental behaviour of flexible pavements under various loading conditions. Bryan taught at the University of Canterbury from 1986 to 1998.

Bryan commissioned the Canterbury Accelerated Pavement Testing Indoor Facility (CAPTIF) and the University's transportation laboratory. He also established the first national laboratory for measuring polished stone value (PSV) to measure the degree and speed at which stones 'polish', and hence provide less friction for tyres. As a direct result of this work, all New Zealand quarries have since been required to routinely PSV test their stones. Bryan has also been a member of the AUSTROADS Pavement Task Force (and its preceding groups) for two decades, providing an Australasian-wide perspective on road surfacing friction. He has been central in advancing the use of calcine bauxite (an aluminium by-product) and Glenbrook Melter Aggregate (GMA), a by-product of steel industry in road surfaces for greater friction.

His work in designing safer road services is a constant balancing act. For example, while more voids in a surface generally mean more adherence between tyre and surface (and lower noise), this also allows more water to enter the paving and begin to reduce adherence qualities. In a country that allows a minimum lower tyre tread of 1.5mm (compared with as much as 5mm in Europe), New Zealand's roads have to do much of the work of helping vehicles remain on them.

A strong advocate of road shoulders and increased surface smoothness, Bryan has also had to balance such value-added road features with cost and the need to save lives.

He is a widely acknowledged leader in research into recycled plastic and rubber in roads on both sides of the Tasman, for performance and environmental gains. Another focus has been advocacy for the use of emulsions in road sealing, as against the traditional 'cut-back' technique. This allows roads to be sealed at considerably lower temperatures, removing the need for highly combustible kerosene.

Innovation in vehicle safety

Designing greater safety into a truck fleet

It follows that the vehicles we use are critical health and safety considerations. That's why Fulton Hogan's Certified Safe programme takes standard trucks and makes them safer.

Certified Safe designs safety into vehicles, and is part of Fulton Hogan's vehicle management and conditions of use standards. It reflects that while standard safety features in cars and utilities have proliferated in recent years, trucks of more than 3.5 tonne have lagged behind in this important respect.

"The absence of standard features like automatic park brakes and park brake alarms has been selling our people short," says Mechanical Engineer Graham Eaton.

"Although new top-end trucks now have safety features equivalent to modern cars, it would take considerable time for our replacement programme to have all trucks meeting the safety standard we seek."

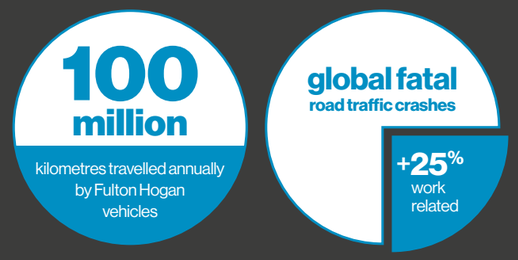
In New Zealand, Fulton Hogan has fast-tracked this process by ensuring its 1,500 trucks have the same additional safety features, irrespective of their age. The goal is the verifiably safest plant on the road, and on construction sites, and the safety outcomes are monitored region-by-region using a live health and safety dashboard.

Certified Safe's standards have been revised and upgraded more than 50 times as new needs have been identified. After-market safety additions include park brake alarms, with internal and external warnings, deck props for tipping bodies, tail door trip, and lock release-warning lights/alarms, ground-operated tarps to avoid trips and falls, and lockable battery isolation switches for lock out/tag out.

Certified Safe inspections occur six monthly which, together with operators' daily pre-start inspections, ensures the added safety features are always operational. Without a current Certified Safe label, or subcontractor plant induction sticker, a vehicle may not be used.

Tangible results:

- All trucks now have the same safety features, irrespective of age.
- Fulton Hogan's minimum standards for plant and truck safety are now regularly used by partners on joint venture projects.
- Subcontractors' trucks must have a park brake alarm before being permitted on sites.
- Certified Safe has been extended to Fulton Hogan's non-road going vehicles such as loaders, rollers and excavators.
- Although accidents are multifactorial, Fulton Hogan's total recordable injury frequency rate (TRIFR) has more than halved to 5.0 over the past decade. In the last full year, mobile plant incidents fell 24.4%, all safety near misses by 36.2%, and mobile plant near misses by 51.2%.



2020 AUSTRALASIAN FLEET CHAMPIONS AWARDS

Fulton Hogan was a stand-out at the 2020 Australasian Fleet Champions awards in November. The awards, run by Brake – the road safety charity, honour people and initiatives that reduce incidents involving at-work drivers and vehicles. Fulton Hogan Technical Director – Pavements and Materials Dr Bryan Pidwerbesky won the

Outstanding Contribution to Road Safety

award for his 30 years' service to designing safer roads, and Fulton Hogan's 'Certified Safe' won the

Safer Vehicles

category for its programme of retrofitting safety features into the fleet.

Innovation in Covid-19 risk mitigation

Leading in QR tracking from day one, at Ōhakea

The rapid onset of Covid-19 required quick thinking to solve various problems that, only weeks earlier, were far from front-of-mind.

One of the most timely, launched on the morning of day one of the Alert Level 3 restart following lockdown, was developed by Alex Slabbert, a site engineer working on Te Whare Toroa, an upgrade project at Ōhakea air base. Alex developed a QR code-based Covid-19 tracking system to capture, in digital format, all the information required under the Alert Level 3 restart protocols, thereby avoiding manual recordings, with all the associated touch point transmission risk.

Alex developed a Google forms process with a QR code-based sign-in system. Inducted personnel were pre-loaded in the system, to allow easy selection of individual's names and other details via drop down menus.

In addition to gathering this information, the system also delivered key information slides on Covid-19 hygiene and distancing when scanning into the site, as well as information about hygiene at home and social distancing.

"The ability to consistently deliver key information was invaluable and ensured required standards and expectations to keep everyone safe were reinforced daily," says Ōhakea Project Director Reuben Saathof.

The QR code can be scanned with any camera mobile device – if someone doesn't have the device, a security representative onsite can scan them in and enter their details. Visitors and deliveries have a customer process within the system, requiring additional information. The system generates a time-stamped entry with all the details each time someone scans in.

The content and information was modified as the country changed alert levels. The system can be customised for any Fulton Hogan site, and applied throughout the business.

"As a project, we are currently looking at further customisations, including a QR-based sign-on to risk control plans and delivering key site weekly safety toolbox information and safety messaging communicated directly to site staff and teams via a daily sign-on code," says Reuben.

Ōhakea air base, 25km north of Palmerston North, is where Fulton Hogan is building a new heavy duty apron and improved taxiways for the Royal New Zealand Air Force. This will enable the introduction of larger Poseidon P-8A aircraft in 2023, to replace the 1960s-era P-3K2 Orions.

Innovation in rock control

How to stop the sky from falling

Planning and building the South Western Alliance's Victorian rock fall attenuator on the Great Ocean Road makes it a 'how to' guide for future rock attenuation projects in challenging locations.

The South Western Alliance is a partnership between Regional Roads Victoria and Fulton Hogan. The alliance maintains and manages the arterial network in the state's southwest. A geotechnical survey in 2018 identified a site at Cumberland River with a high risk of rock falls from the cliff-face above the road.

It commissioned Swiss-based designer Geobrugg, the global leader in high-tensile steel wire safety nets and meshes, to develop a stainless steel system for maximum durability in the marine environment. The drape netting attenuator needs to be installed without disrupting traffic on this iconic Australian tourist route, with around 6 million visitors annually.

It also required sensitivity to the site's environment, extensive safety measures, and significant geotechnical planning. The worksite was a narrow, winding section of the road, where the cliff face is sheer and up to 40m high.

For traffic continuity and safety, a temporary barrier wall of containers, 17 long and two high, was installed. The bottom layer was filled with water filled bladders for strength and stability, with the containers anchored to the cliff by steel rock bolts up to four metres long drilled into the rock.

Specialist workers rappelled down the cliff face to remove 5,700 tonne of rock from the fragile cliff face using pneumatic drills to inject expanding grout or airbag jacks to crack rocks for removal. The cracked-out rocks were dislodged individually with crowbars before falling behind the container wall.

After removing the fallen rock and the containers, the alliance widened the roadway to allow a permanent two metre wide 'catch zone' at the base of the cliff.

Installing the attenuator began in late 2019. It comprises nine steel beams of up to five metres long projecting from the cliff face to support the drape netting. The abseiling workers anchoring the cliff face with 30 steel bolts, up to nine metres long, using portable tripod drills. An extended section of the lower cliff face was treated with shotcrete to bond the surface.

Installing the attenuator and netting, which required the use of a 100 tonne crane, was completed in early 2020.

A 200m long and 1.1m high catch fence supplements the netting, and enables maintenance crews to relatively easily remove any rock that falls in future, using an excavator.

It was almost exactly 100 years ago that the Great Ocean Road was completed by veteran WWI soldiers.

Greg Grima, Project Manager on the South Western Regional Surfaces Transport, Department of Transport, says this history was in the back of people's minds as they worked on the project.

> **"We are proud to be building on the legacy of our diggers some 100 years ago, except we have the benefit of modern equipment and innovative technology, rather than picks, jackhammers and explosives.**
>
> Project Manager Greg Grima.

> **When you step off the plane after landing on the ice sheet, your first glimpse of Antarctica is life changing.**
>
> **From then on, everything else is mind-blowing.**

Canterbury Quarries Development Manager Quinn McNab led the five-person Fulton Hogan team at McMurdo Station in early 2020, crushing, stock piling and screening aggregate.

Innovation in health and safety

Extreme test of our health and safety processes

For the Fulton Hogan Board to allow staff to work in this challenging role in the world's harshest environment, health and safety was the over-riding consideration. Largely for this purpose, Fulton Hogan Quarry Managers Mike Earnshaw and Gavin Hartley made a preliminary visit in Spring 2019, to assess the crushing site and the equipment, and to understand logistical requirements.

"In addition to the realities of working in a hard rock quarry in the Antarctic, we were working with a number of subcontractors who were new to each other," says Quinn. "Down there, keeping the whole team safe by understanding exposure to risk and injury, and how to get people home in the event of an accident, was paramount."

It was the first time Mount Erebus basalt lava flow rock had been drilled and blasted at McMurdo, with the blasting, loading and hauling done by American contractors. The American teams adopted Fulton Hogan's Living Safely safety protocols that were developed for New Zealand conditions.

"Such was their regard for Fulton Hogan's health and safety culture and processes, the main subcontractor asked us if they could use our health and safety programme for the entire quarry operation," says Quinn.

"Everyone bought into Living Safely, and we were more than happy to share it. Living Safely became the wider team's 'Bible', because it removed subjectivity and gave consistency across the companies working there."

Canterbury Quarries HSQE Manager Lisa Wakefield says the risk control plans for the quarry management were little modified from those used in New Zealand.

The two variances were reliance on other parties for emergency procedures – the Americans had their own doctors, fire brigade and full day emergency management induction - and an additional emphasis on wellbeing.

"With the team away from families in an alien environment for a long time, mental health and wellbeing were primary considerations," says Lisa.

"In addition to the team members keeping in close contact with their families back home by phone and email, Quinn kept in touch with team members' families and encouraged open conversations between the team members about how they were doing. Having shared accommodation was also a positive for maintaining connectedness."

The delivery of care packages of New Zealand treats was a reminder that they were not quite so far from home.

"There's nowhere else on earth that you are so isolated and you can't just pick up sticks if you want a break," says Lisa.

Quinn says setting up and operating the base course crushing plant at McMurdo was "an awesome opportunity for the guys – a career highlight for us."

"The fact it didn't take long for life there to become second nature suggested we got the systems and approach about right.

"You'd be on the digger thinking you were in the quarry at home, then look up and see Mount Erebus towering above you and say 'that's right, I'm in Antarctica'."

McMurdo Station is one of three permanent United States Antarctic Program research facilities managed by the United States National Science Foundation. More than 60 years old, it is undergoing a major rebuild under the United States-funded Antarctic Infrastructure Modernization for Science (AIMS) programme.

Innovation in education

Water as the source of life – and of learning

Science, Technology, Engineering and Maths (STEM) are building blocks of the water industry. So too are the young minds that will shape its future. This is why Fulton Hogan Utilities are working with local primary schools to pioneer practical, problem-based STEM learning initiatives.

Working with teachers at, among others, Edwardstown, Seaview Downs and Brighton Primary schools in Adelaide, students are exposed to real world challenges on existing water projects, and encouraged to work collaboratively in solving them.

“When students are so deeply engaged that they are challenging themselves to think more critically about the subject and then come up with creative solutions, this seems to help them to intrinsically develop the critical and creative thinking skills that we want them to have,” says Christie Evans, Assistant Principal in charge of STEM and numeracy at Brighton Primary School.

Fulton Hogan Utilities Water Pre-Contracts Manager Dave Evans says that although the study of STEM and our natural resources are both part of the primary level curriculum, students seldom get to apply their knowledge and understanding in the real world.

“It’s well recognised that students retain knowledge longer when it’s practically applied. As the water industry becomes more technology dependent and environmentally sensitive, this knowledge will only become more important,” says Dave.

After being presented with a real project challenge and visiting the live project site, the children develop questions, ideas and design solutions. Fulton Hogan engineers provide ongoing support, including school visits, to discuss these ideas and to help guide learning and solution development. The students’ designs are reviewed by Fulton Hogan Utilities engineers, before they present their solutions back to classmates, client representatives, members of Fulton Hogan, teaching staff, senior Department for Education STEM co-ordinators and, in some cases, local and state government ministers.

To date projects have included:

- **Katfish Reach – students were asked to develop a temporary flow path around a construction site to deliver a constant supply of 60 million litres of water per day to end users, whilst being mindful of minimising fluctuations in the Murray River level and protecting Eckert Creek bank stabilisation works and the natural ecosystem.**
- **Riverine Recovery project - students from grades four to six were given drawings, specification timelines and key criteria to meet the challenge of building an accessway to a lagoon to facilitate construction of a water regulating structure.**
- **Tank restoration in South Australia - Students were asked to repair a nine million litre water tank while it remained in service. They visited SA Water’s Seaview tank facility and the tank rehabilitation there, helping them see first-hand the engineering and environmental considerations, before developing their plans.**

Fulton Hogan Utilities has also worked with the Department of Education to produce videos outlining the programme to help other schools understand the benefits of delivering problem-based STEM learning at primary level in this practical way.

Often project activities also have an Indigenous consideration, particularly the importance of land and water to Indigenous people and the implications of construction on lands with cultural significance.

“Solutions involve considering, for example cultural heritage zones, native plants and tree protection for sensitive environmental and sustainable outcomes, which is really important for young people to understand,” says Dave.

A modular handrail system that clips to the top of the maintenance hole form, without the need for bolts.

The engineered handrail system fits any size of maintenance hole forms, reducing hazards and safety risks at heights.

Innovation in maintenance hole construction

South East Water’s pipes and structures program

When Fulton Hogan was asked to provide sewer services involving the construction of deep gravity sewers up to six metres deep to 111 properties, for the Officer Backlog project, the project team began thinking.

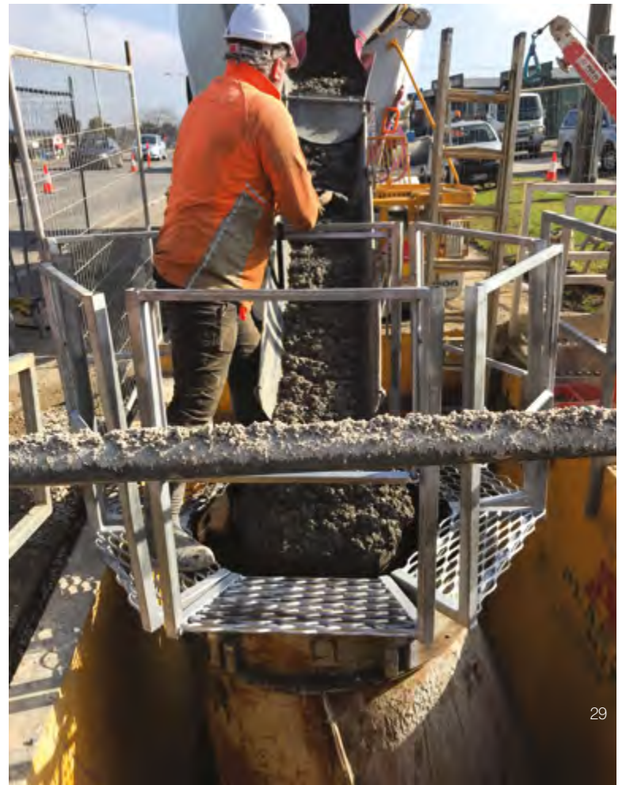
Maintenance hole construction safety has been a vexing issue for some time. How to make it safer than existing maintenance hole construction methodology for workers was the question. Even though current safety procedures mandate every maintenance hole worker wearing a safety harness attached to an inertia reel on a portable davit arm, there’s still risk of an injury if they slip.

It was on avoiding the effect of slips that Project Manager Matt McJannet, Site Supervisor Mick Lillywhite and Manhole Subcontractor Baskim Rexha were most focused, by improving worker safety on top of the forms.

Their solution addressed the fact that maintenance hole forms typically need to fit inside shields required to protect excavations from collapse. Shield placement, especially for backlog sewers, is frequently difficult, and is often required to avoid obstructions such as services and road structures.

As a result, the shields are often irregularly orientated, and with varying clearances to the maintenance hole forms. Therefore, a modular and highly adaptable solution was necessary.

The team developed a modular handrail system that clips to the top of the maintenance hole form, without the need for bolts. The engineered handrail system fits any size of maintenance hole forms, reducing hazards and safety risks at heights.



Innovation in roadworks safety

Taking manual traffic controllers from the danger zone

From 1 July 2020, Fulton Hogan's manual traffic controllers (MTCs) began using eSTOP remote controlled traffic lights, safely away from the danger zone.

The deadline for removing traditional hand-held stop/go signs was announced in late 2019 and, as far as practicable, all Fulton Hogan roadworks have used either eSTOPs or 'Gibney paddles' since then. The Gibney system is a stop/go sign on a long arm, which keeps the MTC well away from the traffic. Traditional stop/go signs may still be used in emergencies.

Fulton Hogan is the first major contractor in New Zealand to commit to taking all MTCs away from the danger zone, and is distributing the eSTOP technology New Zealand-wide through its Signs and Graphics division. Much of the credit for eSTOP goes to Canterbury Contracting Services Manager Damien Houlahan and his efforts to enlist Waka Kotahi's support for the technology.

Fulton Hogan Signs and Graphics National Account Manager Thomas Holdaway says the eSTOPs are selling so fast "they're gone before the ship has docked".

Fulton Hogan Australia aims to have all MTCs off high risk roads by the end of 2020.

Innovation in road safety management

New road safety app highlights safety risks

> "Understanding where serious hazards are is a key step in managing safety proactively."
>
> Road Safety Manager Ryan Rolston.

A road safety engineer using Fulton Hogan's new road safety app would report numerous safety risks in this scene:

- The wooden sight rail gives no protection from the bank and the sea below, and needs maintenance.
- There is potential for pedestrians to be on the roadway, with limited visibility from any passing traffic.
- The pedestrian warning sign should be placed further up the road, in advance of the hazard.
- Loose material on the edge of the traffic lane could cause vehicles to lose control.
- An empty white post suggests a sign or chevron is missing.
- Foliage is obscuring visibility on the bend.

The new road safety app has been developed for engineers to identify and record these sorts of risks, and has been trialled on the Marlborough Roads NOC. Fulton Hogan Engineering Solutions led the development – a collaboration between the GIS team, Road Safety and NOC subcontractor WSP.

Road Safety Manager Ryan Rolston says the focus is on recording hazards that could result in death or serious injury if a crash happens.

"Crash records tell us a lot about safety risks on the network. However, we don't want to rely on crashes happening to know where there is a problem. Understanding where serious hazards are is a key step in managing safety proactively," says Ryan.

The app works on any mobile device, and its smart logic allows users to select from nearly 200 possible problem and solution options. Users can photograph and record audio descriptions of problems, and the app has a severity rating system for prioritising interventions. Using Survey123, the app is part of Fulton Hogan's ArcGIS suite, which means users can map, analyse, filter and export the information they have collected when back in the office.

GIS Manager Sean Smith says the collaboration between Fulton Hogan and WSP was central to the success of the app. "I think this is a case study in co-operation and collaboration. We're looking forward to the results of the pilot and rolling it out across the NOCs."

The challenges and opportunities of biofuel for New Zealand

An insight from Fulton Hogan New Zealand Chief Executive Graeme Johnson

It was a proud moment when, last month, Fulton Hogan took delivery of the first new truck in Australasia to run on 100% biodiesel.

When driver Brendon Congalton was asked what part he was most proud of about the gleaming new Volvo, he didn't hesitate. "It's the clean exhaust pipe," he said.

In just five words, Brendon expressed something both personal and profoundly important in the push to address climate change.

All businesses know fossil fuels are not the way of the future. They are an interim step on the way to a future where we can power our economy, without undermining our ecology. The question, of course, is how to pivot to a future when electric vehicles (EVs) and hydrogen technology, to name just two, are the norm.

For Fulton Hogan, part of that transition is biofuel. It's not well known that we produce GreenFuels® biodiesel - cold-weather capable biofuel made from recycled canola cooking oil in an innovative process at our GreenFuels® plant in Christchurch.

Volume-wise, we currently have the capacity to make around three million litres of GreenFuels® biofuel per year to help power our vehicles and equipment. It's not enough to power everything but, nevertheless, it's an important step for us. Particularly important is that GreenFuels® is genuinely New Zealand made – or should we say re-made. It's a Kiwi innovation that powers machinery that creates infrastructure for New Zealanders, harnessing the principles of biodiesel circular economies.

For us, making GreenFuels® has not been without its challenges.

As pioneers in this area, we have had our share of technical challenges, most of which have been addressed. With GreenFuels®, we are also competing with the vast oil industry, with its proportional economies of scale in extraction and production. The third challenge is the legislative and regulatory environment, with consecutive governments not seeing their way to directly encouraging biofuel investment, despite their commitment to sustainability.

The reason we're committed to GreenFuels® - and are doing what we can to expand its distribution around New Zealand to include supplying major clients like Watercare in Auckland - is that we know the time of alternative energy is upon us.

> We've shown that biofuel is technically proven and viable - it's in use in our vehicles and plants, and those of customers.

We've demonstrated that, with more scale, it's a real option for New Zealand, as we wean ourselves off fossil fuels.

Although a modest start in the context of our, and our customers', overall use of fuel, GreenFuels® can be a catalyst for a wider and more fundamental move to environmentally sustainable biodiesel production. The New Zealand Biofuels Roadmap developed in 2018 by Scion makes interesting reading in this context, in that a genuine and sustainable alternative fuels industry requires;

"National strategic and corporate leadership to build a biofuel consensus and impetus to develop long-term planning and implementation to put all the components in place. The market alone will not bring about a biofuelled future for New Zealand. The level of forward-thinking, commitment and investment required means it is difficult for significant biofuel production to come into being without strong leadership to initiate and implement major components in a strategic national plan."

The benefits of such "forward thinking commitment and investment" go further still. Less obvious at first glance, but no less important, is the ripple effect that sustainable fuels can have through to the marketability and value of what New Zealand produces. Take, for example, the fish caught and marketed by GreenFuels® client Okains Bay Long Line Fishing Ltd.

Okains Bay's owner Greg Summerton is a 35-year long-lining veteran. Of Ngai Tahu descent and with an ancestry in long line fishing that goes back more than 150 years, his business is built on kaitiakitanga – respecting the fish, the community that catches and processes them, the environment we share, and the energy we use to recover them.

Greg says powering his boat Kawatea with blended GreenFuels® is central to this kaitiakitanga, and part of the reason his fish is sold in North America up to eight months before it's caught, at a significant premium. Globally, people are prepared to pay a premium for ethically caught fish.

Greg's attitude is embodied in: 'Toitu te marae a Tane Toitu te marae a Tangaroa Toitu te iwi' - if the land is well and the sea is well, the people will thrive.

And so it can be for virtually anything New Zealand produces. What better additional reason is there to want to help de-carbonise industry? Fulton Hogan, for one, is applying a culture of problem solving, honed over 87 years in business, along with emerging technologies to help do our bit to ensure the land is well, the sea is well, and people are thriving. By getting this right, we'll also help ensure New Zealand's economy is thriving.

For government and business alike, biofuel production and use is a step we can take right now. We are keen to work with the public and private sector in investing forward to unlock the 'pivot' potential of this technology. We'd love to increase capacity, distribution and supply with other like-minded entities.

The result would bring enumerable benefits, reducing our carbon emissions in line with the Paris Accord and New Zealand government goals, reducing waste and encouraging recycling, and reducing reliance on imports. It would also help spur the sort of technical and process innovations necessary for sustainable solutions to advance the value of the products we export.

These are compelling and realistic goals, based on existing technology.

Innovation in alternative energy

Collaborative challenge leads to greener truck

After challenging SEA Electric to develop a truck powered by electricity and generating its own sustainable electricity to power ancillary power tools, Fulton Hogan has taken delivery of this four-wheeled innovation.

Working with ORIX Australia, discussions with SEA Electric began in mid-2017. The primary considerations were battery life, travel range, and the ability to power all tools, without the need for a fossil fuel-powered generator.

Port Phillip was selected as a suitable location, replacing an ageing diesel truck that had a petrol generator and which had been averaging 90km per day installing street signage and public bin surrounds.

It was the first time SEA had been asked to develop an electric truck with an inverter to power electric tools.

“The SEA Electric team had some fun bringing this idea to reality,” SEA Electric Regional Director of Oceania Glen Walker. “We joked we have just built the world’s most versatile zero emissions power board.”

The cab and chassis is a Hino 917, provided to SEA Electric as a rolling chassis, without engine or gearbox. It is powered by the SEA-Drive® 100 power-system, with a 100kWh battery capacity, producing 108kW maximum power. It produces maximum torque of 1,000Nm and has a range of up to 275km (unladen). The onboard three-phase charger can be charged to 80% within five hours, and has CCSD DC fast charge.

Battery recharging is via a three-phase plug, and fast charging is available using the installed type two plug, and the battery life is estimated to be between seven and 10 years.

The body was designed in consultation with the truck operators for ideal placement of tool boxes, and to incorporate an electric lift tailgate to reduce manual handling.

Innovation in biofuel use

Fulton Hogan takes it to 100%

Australasia’s first ‘B100’ truck – designed to run on 100% biofuel – is now on the roads around Christchurch. The Volvo 500 is running on GreenFuels® biodiesel produced by the Fulton Hogan subsidiary in Christchurch.

Driver Brendon Congalton says it’s been turning a few heads, with some powerful graphics developed by Fulton Hogan Signs and Graphics. Despite driving what is effectively a ‘mobile billboard’ for sustainability, Brendon says it’s the “clean as a whistle” exhaust pipe he’s most proud of.

Canterbury Regional Manager Stephen Lowe says the visibility of the special Volvo around Canterbury is raising awareness of the steps Fulton Hogan is taking with biofuel, and is an early opportunity to work with companies like Volvo to understand the potential of 100% biofuel use.

Innovation in alternative energy

Steep learning curve with electric truck in Dunedin

Fulton Hogan's new LDV EV80 electric truck's road maintenance circuit includes the world's steepest street – Baldwin Street, in Dunedin.

Purchased as a cab and chassis, Auto Transform Ltd fitted a tool box and alloy deck in Auckland before it was transported south to Dunedin. It's one of three trucks, the others being diesel Mitsubishi Canters – used for cyclic maintenance in the CBD and harbour area, on behalf of Dunedin City Council (DCC).

DCC Maintenance Operations Manager Thomas Forde says the LDV EV80 can run for up to two days on a charge, depending on work load, and recharges in around six hours. It can also be plugged into public fast charge stations when necessary.

Thomas says although EV cars are becoming common, the truck is attracting quite a bit of attention. This includes a request for a trial by the Port of Otago, which is considering a similar vehicle.

He says the LDV EV80 is adequate for its relatively light duties, and estimates it is running at around 80% capacity to achieve what the diesels achieve using 50%. To keep weight down, it doesn't have a tilt deck, which it doesn't need for its duties, but would obviously be an issue for a truck destined for heavier duties. Based on the lease cost, electricity costs and R&M, the return on asset is similar to that of an equivalent diesel vehicle – and the return for the environment considerably greater.

Innovation in in-house sustainability development

Quietness descends on West Coast quarry

What's large, noisy, needs regular refuelling, daily servicing, ongoing maintenance, and burns through 80 litres of diesel an hour.

That'd be the diesel-powered generator at the Sids Road quarry near Greymouth.

But, no more. In its place is a brand new in-house designed 'plug and play', hard-wired mains-power system. Gone, too, is the need for overhead conductors and poles, with the main switchboard located on the site boundary and linked to a 500 amp sub-main by 70m of ducting to a fixed distribution box.

The new switchboard was designed by the project team electrician, and made to the required specification by IC Switchgear in Christchurch. As part of the upgrade, the site was also able to use the Power Factor Correction (PFC)† available, making the operation more efficient by providing automated capacitance on demand for the electrical load.

The team say the benefits are piling on top of each other. They include nil CO^2 emissions, no overhead power conductors, no refuelling or risk of spills, less noise, much less servicing, reduced power demand because of PFC, and a longer operating life. All this, and remaining portable, if needed.

Using in-house design and installation achieved further savings and allowed it to be delivered ahead of time, 50% below the cost of the original estimates. Aside from the running, maintenance and depreciation savings, early estimates indicate a direct monthly cost savings in the order of $2,000/month to run the plant under the new configuration.

> **"The project shows how local, in-house involvement can produce cost-effective, durable and tangible contribution to sustainability within the business.**
>
> **The project has been delivered under-budget, using largely local knowledge, innovation and skills.**
>
> West Coast Operations Manager Garry Wells.

† ***Power factor*** *is an expression of energy efficiency. It is usually expressed as a percentage - and the lower the percentage, the less efficient power usage is. Power factor (PF) is the ratio of working power, measured in kilowatts (kW), to apparent power, measured in kilovolt amperes (kVA).*

Power Factor Correction *is a technique which uses capacitors to reduce the reactive power component of an AC circuit in order to improve its efficiency and reduce current and therefore reduce costs.*

Innovation in waste re-use

Waste not, want not

The $630 million Albion Park Rail bypass in Wollongong is a showcase for open mindedness on alternative sources for raw material, and blending various used materials for better environmental outcomes. Reapplying various waste streams into this major project has significantly reduced waste to landfills, carbon emissions, and the need for virgin quarried material.

"We have a problem in New South Wales with waste stream recycling. We need to find alternatives, and this is one on a major scale," says Fulton Hogan Regional Environmental Manager Sam Leigh.

"Waste materials, if carefully and appropriately handled, are a practical input into road building, particularly given roads' long term design life."

The project, for Transport for NSW (TfNSW), is by Fulton Hogan Construction, with support from Fulton Hogan Infrastructure services (pavement construction). It extends the M1 Princes Motorway between Yallah and Oak Flats, and bypasses Albion Park Rail, completing the missing link for a high standard road between Sydney and Bomaderry.

The project is, quite literally, breaking new ground in the innovative re-use of materials, and sets out to achieve an excellent rating from the Infrastructure Sustainability Council of Australia (ISCA).

The project team has been working with ISCA and the NSW Environment Protection Authority (EPA), and the achievements to date have been recognised by the TfNSW delivery team.

"TfNSW is committed to looking at ways to increase the use of recycled materials in transport and building projects, and to promote more sustainable methods during construction," says TfNSW Project Manager Warren Blacka.

"Fulton Hogan's commitment to great sustainability outcomes on the Albion Park Rail bypass project has been demonstrated through the re-use of many materials that would have otherwise been waste product. TfNSW hopes positive outcomes achieved at Albion Park Rail bypass will assist in driving the market and stimulating innovation across the waste and infrastructure industries."

Albion is a 'net import project', due to the shortage of suitable topography to cut-to-fill. Fortunately, several major inner city and local mining projects have been generating excess spoil, and the team secured more than 1.4 million tonne of this material that was otherwise likely to be consigned to landfills. All of it was acceptable for re-use under the Environment Protection Agency's (EPA)'s resource recovery orders and exemptions.

In the earthworks layers, general fill contains coal washery rejects (including black shale); tunnel spoil (including Sydney sandstone and estuarine sedimentary material); asphalt millings, used concrete, asphalt and other material drawn from old roads.

The first pavement layer – the Select Material Zone (SMZ) – needed to comply with strict quality specifications around material strength, achieved by blending crushed and screened recovered aggregates from waste construction and demolition materials with waste from local mining and steel manufacturing industries.

The second pavement layer - the heavily bound base (HBB) - has the highest strength requirements. The HBB layer comprises 99% slag, a by-product of the local steel makers in Wollongong. When cured, it sets in a similar way to concrete, and is known for its strength, maximising the long term ride quality of the road.

Project Construction Manager Chris Taylor says typically these layers consist of quarried gravels and large quantities of raw natural material.

"We're producing a higher quality product at a lower or neutral cost, while helping reduce society's footprint on the environment."

More waste products are also going into the asphalt layers. TfNSW has approved the use of asphalt with 25% recycled content and up to 10% washed glass sand, setting a new benchmark for motorways in NSW.

"The team aims to set an example in the State and send a signal to the waste industry that there's a market for specification compliant product," says Chris. "This initiative has been supported by the EPA, with supplementary funding provided by the Waste Less Recycle More initiative funded from the waste levy."

Chris says the team established rigorous processes for quality control and document review and ongoing dialogue and inspections involving the EPA, the client and produce suppliers, with multiple environmental site controls.

"The Albion Park Rail bypass construction team has embraced the four pillars of sustainability, environment, society, culture and economy.

"We're helping alleviate the pressure from societal waste issues, reducing environmental impacts and improving the economics as well."

Chris says the key aspects of a successful waste re-use programme of this sort are:

- Careful negotiation and clear contractual conditions with suppliers.
- Open liaison with government stakeholders.
- Developing and using careful due diligence processes.
- Robust environmental site controls, including maintenance and monitoring of run-off management.
- Detailed import and inspection processes including spoil tracking and haulage route monitoring.

"We're producing a higher quality product at a lower or neutral cost, while helping reduce society's footprint on the environment.

Project Construction Manager, Chris Taylor.

BY WASTE TYPE

Waste type	Formation	Tonne
Coal wash	Earthworks	483,171
Tunnel spoil	Earthworks	293,527
EPRM	Earthworks	118,179
ENM	Earthworks	91,532
VENM	Earthworks	90,753
Commercial recyclers general fill	Earthworks	43,941
Crusher dust	Pipe backfill	40,000
HBB	Pavement	184,320
Commercial recyclers SMZ	Pavement	87,000
Recycled asphalt (RAP) back into asphalt	Pavement	12,000
Recycled glass sand into asphalt	Pavement	5,000
Commercial recyclers light weight fill	Bridge backfill	7,200
Total waste material incorporated		**1,456,623**

Innovation in solar generation

Solar brings bright ideas for Capital Journeys®

Fulton Hogan's new 5kW (6.3kVA) mobile solar unit in the off-the-grid Kapiti yard in Wellington is bringing even more than sustainable power.

With Waka Kotahi and WSP, Fulton Hogan forms Capital Journeys® - the region's road maintenance team. One new aspect of Capital Journey®'s service is its incident support unit, a mobile unit that is quickly on hand at significant network events that require short-to-medium term site communications and welfare presence from response teams.

While in its base location, the unit is powered by the sun, which also charges on-board batteries, so it is ready to go at any moment. The Fulton Hogan team has pioneered a switching system at the Kapiti yard, which means the mobile incident support unit can be disconnected and recharged without a New Zealand electrical code of compliance for the electrical installation (battery, power inverter and power management system) each time.

In another innovation, solar panels have been installed on one of the region's breakdown workshop vehicles. This means small plant can be run without flattening the truck's batteries, and removing the engine-driven 240v charging system saves fuel and reduces sound and air pollution.

The Kapiti development follows the installation of 10kW (12.5kVA) solar panels on Fulton Hogan's Masterton office's roof, and plans for solar on the Rongotai depot, Wellington.

Fulton Hogan's largest solar installation in New Zealand is at the Reliable Way laboratory in Auckland which, with batteries, is sufficient to power the entire laboratory.

Innovation in project broader outcomes

Building a wetland with the Huntly Bypass

Fulton Hogan Supervisor Alan Rhind talks about a particularly rewarding job – the Fulton Hogan team creating a four hectare wetland on the Huntly Bypass section of the Waikato Expressway.

In creating a haven for wildlife and native plants on the Waikato Expressway, we've discovered how quickly we can make a big difference to local ecology.

With Auckland-Waikato Fish and Game, we've created a home for ducks, kotuku, swans, geese, royal spoonbill, plovers, pied shags and swallows, as well as native plants.

Our first challenge was excavating 35,000m³ from a bog – lowering the water table to make it possible to use machinery. We ended up cutting deep slot drains across the wetland area, and pumping the ground water to a neighbouring sediment pond. This allowed a crust to form on the surface, sufficient for excavators of between 12 and 25 tonne.

Excavation uncovered tree stumps from a kahikatea forest that was cleared for farming in the 19th century. We positioned these as bird roosting spots, and placed logs on the edges of the wetland to encourage insect life.

In looking for a home for the spoil, we identified an area on a neighbouring farm that's normally submerged in winter. By raising and 'debogging' this land, stock will be able to graze it, without run-off into an adjacent stream.

The wetland required swamp pads for the excavators – there was one chance to get the excavation right, as we couldn't re-enter the wetland floor without getting stuck.

We also built a higher-than-normal perimeter bund to add extra weight to induce settlement and consolidation of the underlying materials to avoid further settlement in future. The preload was placed for six months before it was excavated, allowing the final access track to be constructed on top of the bund.

The results speak for themselves. We're all very proud of the wetland, and our ability to turn it back into a high quality habitat for so many species of birds, animals and insects.

Innovation in Network Outcomes Contract maintenance

Technology that's not rubbish

Solar powered, with automatic compactor and online alerts to Fulton Hogan when it needs emptying, the rubbish bin ain't what it used to be.

In managing the road maintenance contract in Northland, Fulton Hogan is a big proponent of the 'Big Belly Rubbish Bin'.

Kyrin Thomas operates the Busy Bean coffee cart at the rest area at the top of picturesque Brynderwyn Hill near Bream Bay. "The rubbish bin is amazing," says Kyrin. "The litter at the rest area has reduced by around 70% making it much nicer for my customers."

> **Checking the status of the bin remotely at any time and collecting data on its usage, we can efficiently maintain the bins, saving fuel and resources.**
>
> Shaun Hearnden, Operations Manager for Fulton Hogan's Network Outcomes Contract with Waka Kotahi.

Innovation in pathogen management

Kauri dieback requires unique handling of soil

The mighty kauri tree is an emblem of New Zealand, and 'kauri dieback' a cause of national concern.

'Kauri dieback' is caused by a microscopic fungus-like organism – *Phytophthora agathidicida* (PTA) – which infects kauri roots and damages tissues that carry nutrients and water.

So, when it came to resealing SH12 through Waipoua Forest on the west coast north of Dargaville, home to New Zealand's largest kauri, Tane Mahuta, sensitive handling was key.

Through the ancient green world of towering trees and rare bird-life, Fulton Hogan's Northland NOC team (Northland construction, sealing and traffic management, with pavement repair assistance from Gisborne) resealed 23km of highway through the forest, with all material in resealing considered as infected.

Because of the kauri dieback, all spoil, vegetation, digout and milling material, pavement and base course material was deemed to be 'soil', and treated as infected with PTA.

The soil needed to be disposed off-site, transported in trucks with bins double-layered with 200um Polypropylene liners, securely sealed and covered with waterproof tarpaulins. Afterwards, the truck decks were water blasted to be free of soil remnants, then treated with a 2% SteriGENE solution.

In addition to the resealing, it included eight dig-outs with first coat sealing (760m^2), 38 in-situ stabilisations (including 4,350m^2 of first coat sealing) and 34 mill and fills (2,350m^2).

Work was completed in accordance with the standard operating procedure, with inductions for all Fulton Hogan staff and subcontractors completed by a Te Roroa ecologist.

There's currently no proven cure or treatment for PTA, and the disease is easily spread through soil movements. A pinhead sized speck of soil is enough to spread the disease.

Tane Mahuta (Lord of the Forest) is the country's largest kauri. Around 2,000 years old, it is 18m to the first branch, and is 4.4m in diameter. Nearby is Te Matua Ngahere (Father of the Forest), thought to be even older, at between 2,500 and 3,000 years.

Innovation in heat island effect

A new hue for asphalt

Not only will it (JetBlack®) have the ability to reflect heat… but it can lessen the risk of point loading on the surface

Fulton Hogan Divisional Manager – Airfield Infrastructure & Specialty Surfacing Richard Mihell.

Potholes are jarring, but at airports they can be downright dangerous in an environment when planes are coming in to land around 300km/h.

Fulton Hogan's JetBlack® is an alternative to resurfacing aged pavements and roads. Around 1 million litres is sprayed in airfields across Australia each year on older pavements that have started to ravel, or which have a course surface texture. It's preventative maintenance product that extends the life of the asset.

In some environments, however, the black absorbs considerable heat, contributing to the heat island effect.

To help, Fulton Hogan started to look into a light grey version of JetBlack®. A treatment with all the benefits, just lighter in colour.

Fulton Hogan Divisional Manager – Airfield Infrastructure and Specialty Surfacing Richard Mihell says the new product, JetCool™, is showing early promise.

"Not only will it have the ability to reflect heat, making surfaces cooler and hopefully lessening the heat island effect, but it can lessen the risk of point loading on the surface," says Richard.

A cooler surface will be less likely to develop ruts from slow moving aircraft on aprons, extending the surface's lifespan.

The product is still in development but has been successfully trialled at Adelaide Airport, where they have been looking to mitigate the effects of its heat island effect.

As development continues, the team are excited to see what other applications both JetBlack® and JetCool™ will have.

Urban Heat Island

As our cities get larger, we start seeing the Urban Heat Island effect. Building materials and roads are very good at retaining heat, even at night, making the whole city area warmer than the surrounding country.

The overall effect makes them uncomfortable to live in and can affect air and water quality. It also means that we work harder to cool them down, contributing further to climate change.

Innovation in dust mitigation

Addressing the issue, before the dust settles

An area with low rainfall, hot summer winds and a subdivision on the downwind boundary proved ideal for testing new quarry dust suppression techniques over the summer of 2019/2020. The site was the Parkburn quarry beside Lake Dunstan. This Site of the Future® initiative was a finalist in the Planet section of Fulton Hogan's premium awards, the Good Work Awards.

Led by Environmental Adviser Stu Edwards and Internal Estimator/Compliance Support Manager Adam Garden, the goal was quantifiable environmental, health and safety, and operational gains around the greatest generators of dust-operating plant, vehicle movements, and aggregate stock piles.

The team established solar-powered ultrasonic wind speed, direction and airborne dust monitors along the quarry boundary, to automatically trigger dust management at pre-set wind levels via a wireless link to an irrigation controller and giving real-time, online, dust data.

The system has four elements.

1. **Mist curtain** – A 6m high, 120m long 'curtain', with two pipelines and suspended nozzles at one metre, set perpendicular to the prevailing wind and parallel to dust-prone roads. This covers up to 1.5ha in high winds, without disrupting operations.
2. **Fixed plant mist system** – A more localised mist system on the impactor screen and conveyors.
3. **Wide coverage cannon sprinklers** – 13 cannon sprinklers around the main plant area and stock piles. These each throw 70m, for key traffic movement areas, monitored by a mobile phone app. A 'calm day' programme also activates the sprinklers for short periods.
4. **Stockpile dust management system** – Eight cannon sprinklers on stand-by around the metal stock piles suppress dust from the crushing operation.

Here's what this Site of the Future® initiative showed:

- Because dust needs controlling at source, dust controls have to be strategically located.
- The imperative of right-sized spray droplets (sufficiently heavy to travel, yet not too heavy to drop out of suspension).
- The mist curtain is highly effective in high winds (carry distance and low water use), but in calmer conditions it's of limited value, hence supplementary cannon sprinklers.
- Cannon sprinklers can scour stockpiles, cause potholes and put pressure on water allowances, hence requiring carefully controlled run cycles.
- Stockpiles need to be kept to a minimum size and positioned in sheltered areas and/or within reach of cannon sprinklers.
- Fogging cannons, effectively mobile snow making machines, failed to adequately intercept and engulf dust.
- Recycling water from the processing plant is a useful supplement to consented allowances.
- Chemicals for dust suppression were avoided for environmental reasons, and because base stabilisation polymers are easily disturbed by vehicle movements.
- Other practical measures include sealing haul routes, K-line irrigation for areas outside the four key systems, covering exposed areas with pea gravel, and establishing vegetation to eliminate erosion and dust.

Stu and Adam say they are happy with the early results, and how invested the quarry team has been in dust mitigation measures.

"Dust management used to be an 'add-on' in quarries, now it's as important to get right as the production plant itself.

In the past, every time the wind blew we used to get a bit anxious - now we can all sleep a bit easier.

Internal Estimator/Compliance Support Manager Adam Garden.

Innovation in wastewater filtration

Best in class process, recycled aggregate in Naseby

Central Otago District Council is investing heavily in upgrading its wastewater systems, and among the most recent additions is this new wastewater filtration bed in Naseby.

The approach is top-of-the-line and will ensure an extended operating life. Stantec designed, it has 13 bunded cells, each with actuator control values. The automated fill-and-filter system to discharge the treated oxidation pond effluent to land replaces the previous managed overland discharge. Given Naseby's relative isolation, the system's full automation is also important.

The filtration beds have crushed glass in a crushed glass/ gravel mix in its filtration media. Recycling of glass is a joint focus by Fulton Hogan and the Central Otago District Council, with the glass from Central Otago District Council's kerbside recycling programme crushed at Fulton Hogan's Parkburn quarry.

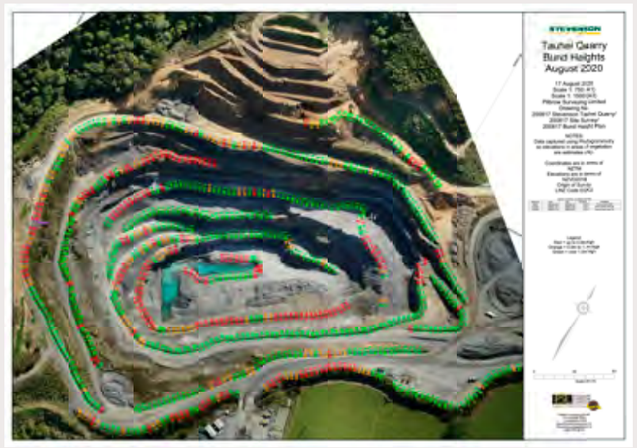
Recently, 30 tonne of glass (that's 9,700 24-packs of beer or 232,800 stubbies) was trialled in 300 cubic metres of bulk fill on the Clyde Wastewater project, being undertaken by Fulton Hogan.

Central Otago District Council's Patrick Keenan says the trial has been a success and the goal is to streamline the process to supply other council-run projects. The Naseby filtration beds are a case in point.

Innovation in quarry safety

Keeping an infrared eye on quarry safety

Bunds on quarry access ways are critical to drivers' safety, and need to be half the height of the largest dump truck wheel diameter in use in the quarry. In addition to daily physical checks of its bunds, Fulton Hogan's Drury quarry is surveying its bunds monthly by drone, using infra-red technology to verify the ground-based checks. The 'traffic light' system shows any area that requires attention, and the results are shared with the operator on site to address.



Innovation in recycling

Bottling innovation

Halting the export of recycling waste is having a mountainous impact, with growing piles of bottles looking for a home across Australia. With this problem, comes an opportunity.

"People have been frantically trying to solve this problem, and one of the obvious solutions is to recycle glass back to what it was originally - sand," says Fulton Hogan General Manager Eastern Region Ben Hayward.

Sand typically makes up between 10% and 15% of asphalt by volume. It is transported large distances to urban sites, often more than 100km, adding a considerable carbon emission burden on the environment. Fulton Hogan has been working with Transport for New South Wales (TfNSW) and VicRoads to modify asphalt mixes to include crushed glass as a sand substitute in asphalt, allowing the raw material to be sourced much closer to where it's needed.

In recognition of Fulton Hogan's leadership in this space, the company has been awarded a $250,000 grant from the NSW government to upgrade its Eastern Creek asphalt plant, and a further $236,000 grant to use recycled glass in asphalt on Sydney's Albion Park Rail bypass project. This was part of a NSW Environmental Protection Authority, Waste Less Recycle More initiative funded from the waste levy.

Minister for Transport & Roads Andrew Constance sees potential to use up to 45,000 tonne of crushed glass in asphalt in the state over the next three years, equivalent to 234 million glass bottles.

Minister for Local Government Shelley Hancock says councils have supported the use of recycled materials in the roads sector, including local roads, and will continue to do so, as part of the NSW Government's plan to increase the use of recycled materials.

"We will continue to work with industry and councils to help develop the supply chain and reduce barriers to uptake in the use of recycled materials in road and building projects," she says.

Albion Park Rail bypass is a marquee site for the use of crushed glass in New South Wales, and involves Fulton Hogan Infrastructure Services and Fulton Hogan Construction on behalf of TfNSW. Crushed glass will make up 2.5% of the bypass's wearing course and 10% of the base course, by volume. This means between two thirds and three quarters of the sand used in the asphalt on the project will have originated as glass.

Fulton Hogan has undertaken detailed laboratory testing of different mixes and particle sizes, with a preference for the finest possible product, as it encapsulates better with the bitumen in the asphalt.

Fulton Hogan has added an additional feeder and conveyor, enabling glass to be blended with reclaimed asphalt pavement (RAP).

"We didn't want the addition of crushed glass to be at the expense of our use of RAP, and we are happily able to use maximum levels of both in the mix."

Ben says one of the challenges ahead in increasing the use of crushed glass as a sand substitute in asphalt is addressing the limited number of glass cleaning and crushing facilities outside of major centres. This is an increasing priority for both TfNSW and Fulton Hogan.

Ben says one of the unforeseen benefits from using crushed glass has been the attitude and response of residents and businesses.

"Inevitably, there is some negative social media commentary whenever there's major road works in a built-up area. But when it's communicated to residents that there's recycled glass in the project, the response is quite different.

"People seem to appreciate the additional effort we and our clients are going to from a sustainability perspective, and this seems to make them more willing to put up with some inconvenience."

> **People have been frantically trying to solve this problem, and one of the obvious solutions is to recycle glass back to what it was originally – sand.**
>
> Fulton Hogan GM Eastern Region Ben Hayward.

Innovation in recycling

Crumbed rubber use in roads helps tackle tyre mountains

Each year, only 9% of the 56 million tyres (450,000 tonne) that reach their use-by date in Australia are reused.

Fulton Hogan is collaborating with councils, roads boards and organisations like the Australian Asphalt Pavement Association (AAPA) and the Australian Road Research Board (ARRB) for a win-win solution to this malevolent mountain.

National Sustainability Manager Rory Bracken says crumb rubber, as a core component of asphalt, has economic and environmental benefits.

“Tyre stockpiles can be an environmental hazard, a fire danger, and a breeding ground for mosquitoes,” says Rory.

“Yet shredded into crumb rubber it becomes an asphalt with greater resistance to surface fatigue, less rutting and oxidative ageing, and more durability. Improved road performance means lower maintenance costs, and reduced emissions of carbon monoxide and methane.”

Fulton Hogan has been working for more than two years to develop wet blended crumb rubber asphalt products under the TyrePhalt® banner. Now in ‘open’, ‘gap’ and ‘dense graded’ mixes, its applicability in different regions and for different purposes is growing.

“Using it across Australia in a variety of applications and in different climates is showing just how versatile TyrePhalt® is,” says Rory.

The products have been developed to incorporate both reclaimed asphalt pavement (RAP) and recycled glass sand.

Use of this product has extended through local government authorities across Australia, including Queensland Transport and Main Roads, and Main Roads in Western Australia.

Jason Hourigan, Regional Manager Infrastructure Services – Northern NSW, says a range of councils in the area have embraced solutions that incorporate crumb rubber, including Central Coast Council and Cessnock Council.

In Queensland, Chris Lange, Technical Manager Infrastructure Services Northern Region, has led a number of projects using crumb rubber, including for early Moreton Bay Regional Council. A trial in a residential street in Elanora for the City of Gold Coast was recognised last year with an AAPA innovation award.

VicRoads, alone, has committed to re-using one million tyres in road works annually across Victoria through to 2024.

Fulton Hogan has more than 30 years’ experience in producing crumb rubber modified binders for spray seals and dry blended crumb rubber asphalt mixes. Working with these products has demonstrated how they can be produced with warm mix technologies, lowering production temperatures, fuming and greenhouse gas emissions.

Innovation in environmental services

Environmental Solutions – problem solving for our times

The launch of Fulton Hogan Environmental Solutions in New Zealand is a further step in the company’s long track record of solving problems, with an eye to the long-term.

It’s a targeted range of tailored environmental services to meet growing client needs provided by Fulton Hogan and selected partners, each bringing particular expertise to solving a shared puzzle.

Environmental Solutions’ services cover:

- Sustainable infrastructure.
- Waste minimisation.
- Resource management.
- Environmental management.
- Climate change effect remediation.

Environmental Solutions General Manager Mark Ford says there’s increasing pressure on all organisations to find new, more environmentally sustainable ways of working and producing goods and services. Fulton Hogan is in a strong position to help others, using its own skills and experience, and those of industry-leading partners.

“Environmental sustainability is the biggest issue of our times, and is likely to continue to be for future generations. The issues are complex and inter-related, and we believe our involvement in modifying environments puts us in a sound position to understand the issues, draw on our experience in addressing them, and to share best practice with others,” says Mark.

With wide practical experience in sustainable product development, stewardship and construction techniques, Fulton Hogan has considerable experience to share. Some of the higher profile product and process developments include GreenFuels®, Recovering Oil Saves the Environment (R.O.S.E.), recycling of asphalt, and development of a range of more sustainable products such as PlastiPhalt® and EmulSure®.

Mark says no business has all the answers, and the key is to work together and to see better environmental practice as a shared, stepped process.

“Although there are common themes in sustainable development, no two of our clients have exactly the same needs, problems and opportunities. Developing tailored or bespoke solutions is central to Environmental Solutions’ approach.

“The immediate focus is on conversations with public and private sector organisations about their problems and opportunities. We’re taking a ‘let’s discuss’ approach to identifying what can be achieved most relevantly, most cost effectively, and most sustainably, in each case.”

Mark says Fulton Hogan’s legacy includes 87 years of addressing challenges and solving problems for the communities it serves.

“We’ve grown and developed by taking a consistently long-term view - the sort of approach you’d expect from a company with three generations of many families. Environmental Solutions is a natural development for a company that modifies environments, and is consistent with our goal of being an enduring infrastructure provider in, connected to, and caring for the communities in which we operate.”

For further information about Environmental Solutions and how it might be able to assist your organisation, contact Mark Ford at mark.ford@fultonhogan.com

Innovation in site remediation and biosolids storage

Environmental Solutions in action

In the Manukau Harbour just north of Auckland International Airport lies Puketutu Island.

Known as Te Motu a Hiaroa to Mana Whenua, it is sacred to the people of Te Kawerau ā Maki, Te Waiohua and Waikato-Tainui, as the first permanent home of the crew of the Tainui waka in Aotearoa.

In the 1950s, the island was valued for another purpose – the scoria and basalt rock that was quarried for projects, including the expansion of nearby Auckland Airport.

On behalf of client Watercare Services, Fulton Hogan and partners are making it possible for Watercare to rehabilitate the island by filling the former quarry with biosolids from Watercare's Mangere Wastewater Treatment Plant. This will eventually create four small hills, replicating the scoria cones that were quarried away. A culturally-significant site will be restored as a future recreational reserve for Aucklanders, and the energy required in the process will be significantly reduced.

Watercare's Mangere Wastewater Treatment Plant produces about 330 tonne of treated biosolids daily, destined for pre-constructed cells in the former quarry. Central to this project is a sealed liner and pump system that will capture and return biosolid leachate to the Mangere Wastewater Treatment Plant.

Now in phase four of five, the kidney shaped base of the liner and the pump station are being installed. The leachate reaches the pump via two gravity lines under the landfill embankment. It is 18.6 metres below ground, with two gravity outlet lines in the pump station at 13 metres and 14 metres, via a soft pile window in the secant piles.

By constructing the shaft and HDD pipes concurrently, the team has shaved 40 days off the project.

The accuracy of the new gravity lines is critical, given the depth and the volcanic geology, the relatively small windows between the pile reinforcing cages and the pipeline operating under gravity flows.

Universal Underground Limited, a specialist in underground utility installation, commenced the HDD pilot hole from inside the facility out through the piles, while Fulton Hogan Civil crews constructed the pile capping beam and excavated the shaft.

Universal Underground and Fulton Hogan's methodology included contracting specialist steering contractor Highside Australia to guide and as-build the pilot hole using sonar-based ParaTrack technology. Because of Covid-19 restrictions, the team guided the drill remotely via a mobile data connection to Australia, upskilling locals to implement the ParaTrack technology onsite. The HDD pilot holes were installed within the design tolerance, and the ParaTrack provided a detailed as-built of the grade of the pilot hole length.

With groundwater flows a risk in the construction of the pump station (proximity to the Manukau Harbour and location below low tide mark), installing the pipelines before excavation allowed the team to seal the penetration in the secant piles with grout before excavating the shaft.

Project Engineer Russell Green describes the project as one of the most challenging and satisfying he's been involved in.

"There's been a need to be flexible given its uniqueness, location and the effects of Covid-19," says Russell. "At times, it's been a case of looking at all the different angles and deciphering a method that's best for what is in front of us."

The pump station is due to be commissioned in April 2021.

There's been a need to be flexible given its uniqueness, location and the effects of Covid-19...

At times, it's been a case of looking at all the different angles and deciphering a method that's best for what is in front of us.

Project Engineer Russell Green.

Innovation in sealing

EmulSure® Seal – three innovations in one

Most innovations achieve a measurable gain in a product or service's performance. It's a rare innovation that achieves three.

Welcome to EmulSure® Seal.

Developed by Engineering Solutions as a Site of the Future® project, EmulSure® is a new means of sealing that's been trialled on a range of sites on Timaru District Council road network over the past 18 months.

The initial motivation was to make sealing safer for operators by reducing the temperature of the seal as it is applied. The EmulSure® system has an additive in the emulsion that allows for faster breaking of the emulsion even at lower temperatures of 80°C. This allows the emulsion to 'fast break', or cure faster, on the road, reducing disruptions to road users.

The second benefit stems from this temperature difference. By halving the physical 'break' time over standard emulsion in certain conditions, EmulSure® Seal allows crews to seal in colder weather than normal, extending the length of the 'sealing season' for more productivity. The reduced physical 'break' time also reduces the risk of environmental impacts with the use of emulsion.

The trials then revealed a third benefit. They showed greater durability through reduced chip loss after sealing and, therefore, the likelihood of less future remedial work.

Over the past 12 months around 1,300 tonne of EmulSure® has been applied in sites around South Canterbury. Following the success in South Canterbury, the trials were expanded to other sites around New Zealand with now over 2000 tonne trialled, including Auckland, Waikato and Dunedin, before the official launch in 2020.

Regional innovation

South Canterbury an innovation cell for Fulton Hogan

Many New Zealanders believe Richard Pearse was the first person in the world to achieve heavier-than-air flight, beating the Wright brothers by nine months, before crashing into a hedge on his South Canterbury farm.

Almost 120 years on, South Canterbury is still innovating. This time, though, it's at ground level.

South Canterbury has become a test-bed region for Fulton Hogan innovations, showing how a regionalised structure, along with progressive clients and a national support system, can drive innovation.

South Canterbury was central to the national launch of the new safer sealing system – EmulSure® Seal. In another step to develop sustainable sealing products locally, the Timaru asphalt plant is being revitalised, making it possible to enable local production of sustainable mixes. From a production sustainability perspective, the plant has long operated with used oil that is collected through the R.O.S.E. product stewardship scheme, and the current enhancements will also help further reduce its carbon emissions.

Timaru District Council's commitment to co-innovation, and the success of their experience with EmulSure® Seal, is leading to further innovation. A new programme for asphalt repair and replacement treatments, based on extensive wear and performance data collected by the Council's land transport team, is underway in South Canterbury.

Fulton Hogan Technical Director - Pavements & Materials Engineering Dr Bryan Pidwerbesky, and the company's Engineering Solutions team are analysing the data to develop a selection flowchart with a range of asphalt solutions targeted at the unique conditions of each site on the local network. This combines national expertise with local data to meet South Canterbury's specific needs.

Fulton Hogan's South Island General Manager Craig Stewart says the Timaru District Council's willingness to innovate is a major factor.

"The key is a council that's willing to partner around new ideas for better wearing, more sustainable roads that give a better long-term return on investment."

Craig says a further example of the region's collaborative and innovative spirit is the establishment of the NZQA-approved Certificate in Commercial Road Transport (Heavy Vehicle Operation) based at Ara Institute's Timaru campus. Fulton Hogan is a founding partner, and has donated a road safety simulator, as well as bringing cadets through the course.

Innovation in airport runways

Trapezoidal grooving takes centre stage

Trapezoidal grooving is the cutting of narrow grooves in an airport's runway for the rapid dispersal of rainwater, more adhesion for aircraft tyres, and increased safety for all on board.

Trapezoidal grooving, as against the traditional 'square cut' (rectangular) profile, has been used in the United States for some time, and there has been some use of imported American consultants to oversee initial jobs in Australia and New Zealand.

Fulton Hogan has led the way in doing trapezoidal grooving in Australia independently, first with Cairns and, shortly, Gold Coast airports. The cutting blades create an approximately 120 degree slope, rather than the 90 degree (vertical) profile of traditional grooving.

Cairns Airport Engineering Manager Steve Willis has this to say of his experience with trapezoidal grooving at the airport.

"Two weeks ahead of schedule, a safety first attitude with a focus on producing consistent, high quality work is a credit to you all. I expect trapezoidal grooving will be the way to go for future works."

Fulton Hogan National Manager Airports/Defence Michael Thompson describes this approach to grooving as simply logical.

"The early feedback from clients has been gratifying, but it is the longer term benefits that will matter most. For airport operators that is where the real value lies."

Based on the experience in Australia, Fulton Hogan is considering opportunities to introduce trapezoidal grooving to New Zealand airports.

5 key benefits

to trapezoidal grooving:

1. Longer pavement life expectancy
2. Increased drainage capacity
3. Being largely self-cleaning there's reduced build-up of debris and reduced need for rubber removal
4. Reduced groove closure
5. Increased skid resistance in the wet

Innovation in piling

Making lighter work of heavy work

Necessity was the mother of invention in building an inner city Christchurch bridge for Christchurch City Council (CCC).

A customised pile hammer dropper was developed by Fulton Hogan's technical services team for the North Frame Pedestrian Bridge, for 'proving' the pile plug in the base of the bridge's 1,200mm diameter pier piles. Plug proving is the process of dropping a heavy weight (generally a fabricated steel hammer) onto a completed pile. The capacity of the pile can be calculated from how the pile reacts to the impact.

Fulton Hogan Civil's largest wet driving hammer is more than 30m long, and weighs 23 tonne. To reach the correct resistance in the proving process, it was only possible to get an 80 tonne crawler crane close enough to the pile. While capable of lifting the hammer with the help of a second crane, this wasn't large enough to drop the hammer in free-fall, without risking significant crane damage due to the rebound in the crane boom as the load is instantly released.

A solution was required for picking up and dropping the hammer repeatedly, without the crawler crane. Phil Wilby and Gil Johnstone from Fulton Hogan's technical services team developed a bespoke mechanism to achieve this that was reviewed and refined by the piling crew, Gavin Styles and James McMillan.

Their solution was a custom friction ring to grip the casing. This was a circular steel band using a smaller 30 tonne hollow hydraulic stressing ram to tighten it around a high friction segmented inner ring to grip the casing. This equipment was fabricated by Fulton Hogan's fabricators in Christchurch.

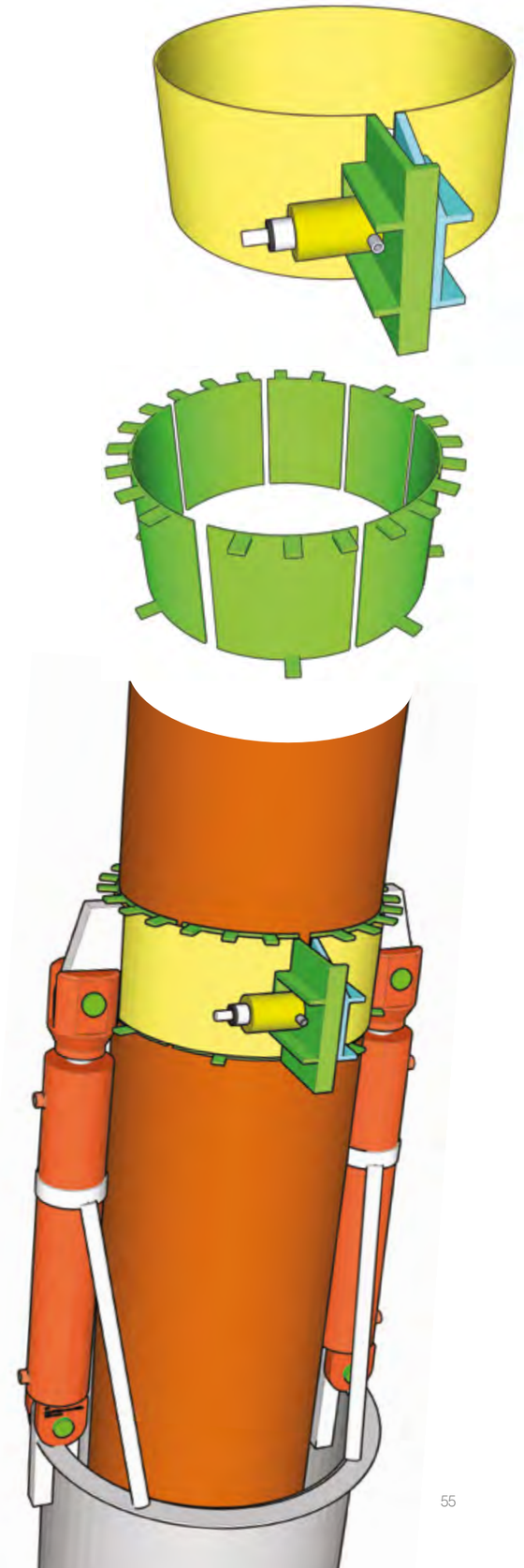
The pressure is kept on the small ram as the hammer is lifted. Once the hammer is at the required height, the pressure on the smaller clamping ram is released and the hammer drops free of the friction ring. The teeth on the inner ring segments ensures that the rings aren't ripped off as the hammer falls. The main rams are then retracted to lower the friction ring before the process is repeated.

While the hammer dropper solved a specific problem for the site, Southern Area Manager Civil James Harrison says it can be adapted to suit other hammer and pile sizes.

"The team has developed a very useful tool that we will be looking to utilise on the next bridge in a few months, and which should free up the crane for other operations."

Its advantages over traditional freefall plug driving include:

- A smaller crane not spec'ed for piling can be used.
- Less wear and tear or damage to the crane.
- The crane can be independent of the plug proving, allowing it to work on other tasks.
- Increased safety as the equipment can be operated remotely.



Innovation in digital technology

Digital Engineering opens up new worlds

Engineering Solution's Digital Engineering team is enabling better pre-start visualisation, more value-based solutions, and enhanced collaboration across the supply chain. The result is increased predictability of delivery, and maximised the cradle-to-grave asset lifecycle. It provides integrated teams with structured project data and greater levels of information transparency, incorporating space, time, and budget to help drive project performance.

Among the most powerful emerging tools for testing the possibilities of projects and understanding the effect of changes is digital engineering, incorporating 3D animation, virtual reality and augmented reality.

Originating in CAD architectural tools, it's now being used in civil works, roads, highways and bridges and, increasingly, for 4D visualisations. These link 3D model elements to a construction programme for detailed construction sequencing and staging.

The next step is 5D visualisations, models that give cost implications of any change, from project specifications to product use, quality goals or sustainability objectives.

"Digital engineering allows us to better understand complex design challenges, thereby more easily predicting the performance of construction sequencing with simulation and visualisation," says National Manager for Innovation & Digital Engineering Chloe Smith.

"This improves data control through a single data source for design in construction, operations, and maintenance. Increasingly, this is also being integrated with GIS."

Digital engineering is also being used for stakeholder engagement, giving clients, local businesses, and communities a clearer understanding of the works to be completed, and how we can minimise disruption to traffic and pedestrian access during these works.

The benefits

1. Improved collaboration and reduced waste – more information, providing a clearer understanding of how engineers, suppliers and contractors can co-ordinate and collaborate for the best outcome on a project - optimising labour, resources, and reducing waste.
2. Improved project controls – greater visibility of potential clashes in construction prior to physical works starting, limiting lost time and money due to early detection and reprogramming.
3. Enhanced visualisation for communications – 3D and 4D modelling provides opportunities to communicate more effectively with project teams, stakeholders and during community engagements, giving greater visibility of the entire construction process and of the completed project.
4. Virtual reality and augmented reality – not only important for communication, it can also be used to train project teams to better understand processes and hazard awareness onsite.

Helping CCC visualise a completed project

Creating the experience that drivers, pedestrians and retailers would have when the Victoria and Hereford Streets upgrade was completed was a key goal of the Fulton Hogan Canterbury team when presenting the proposal to the CCC.

Beth Farrall and Pierre van der Merwe are part of Fulton Hogan's Engineering Solutions team, and developed 3D animated fly-throughs to help the client grasp the full implications of Fulton Hogan's two options.

Project Manager Dan Lucas describes the virtual fly-throughs as "incredibly powerful".

"The team weaved some magic to help the client, and ourselves, visualise the project. This could only lead to a better final result."

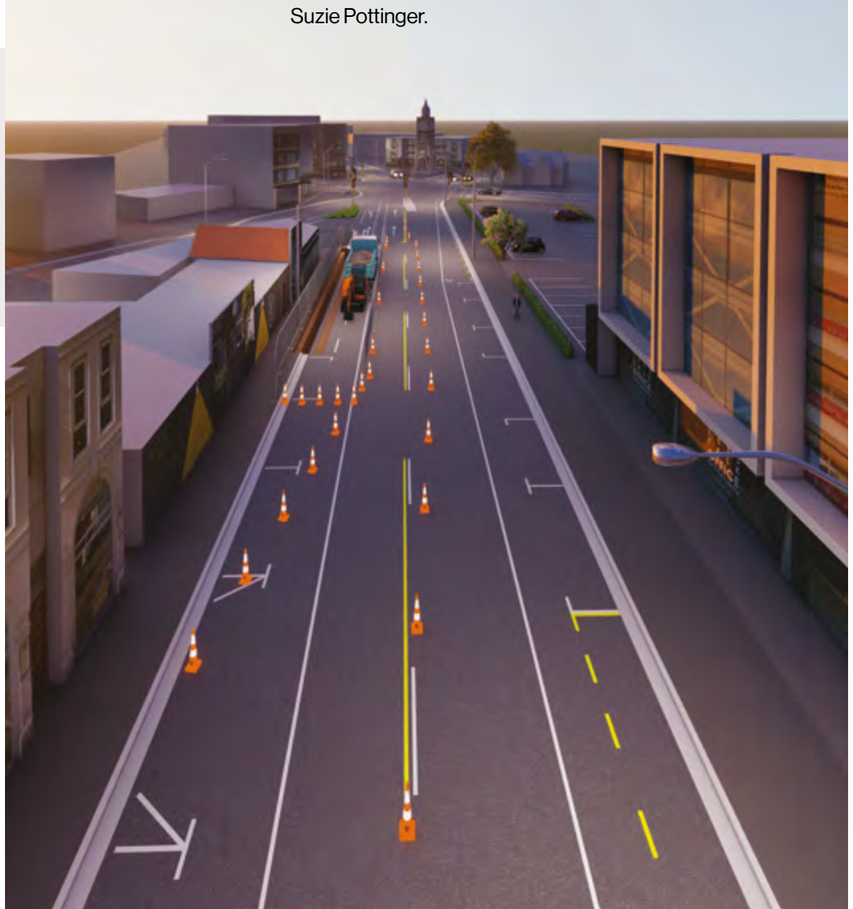
The tender made much of what was learned from the successful $18.5 million Riccarton Road three waters project that was completed in early 2020, also for the CCC.

One of the learnings was, perhaps ironically, how to deal with completing stages early.

"On Riccarton Road, the water installation was completed six weeks ahead of schedule, which had the perverse effect of putting pressure on 'downstream' steps," says Dan. "It showed that it can be as important to plan for things going better than envisaged, as it is for the reverse."

This planning gave the Victoria and Hereford Streets project greater visibility of potential clashes in construction prior to physical works starting, limiting lost time and money due to early detection and reprogramming. Updating progress, new methodologies, and adding in variations as the project progressed, meant project managers had a real understanding of how the project would look when complete, based on the present.

> **Stakeholders are much more likely to buy into the project as a whole if they can visualise what to expect over the coming months.**
>
> **They have a perceived idea of what it may look like, so the fly-through is used to dispel any misplaced assumptions, and clarify the project strategy as a whole.**
>
> Project Stakeholder Communications Manager Suzie Pottinger.



A key means of capitalising on this was having the Victoria and Hereford Streets project proposals divided into small, discrete, parts, any of which could be initiated relatively easily in line with broader timing considerations.

"This approach to project design, along with more timely information, helped the engineers, suppliers and contractors co-ordinate and collaborate for the best outcome on the project – optimising labour, resources and reducing waste," says Dan.

"The fly-throughs were also valuable stakeholder aids," says Project Stakeholder Communications Manager Suzie Pottinger.

"Stakeholders are much more likely to buy into the project as a whole if they can visualise what to expect over the coming months," says Suzie. "They have a perceived idea of what it may look like, so the fly-through is used to dispel any misplaced assumptions and clarify the project strategy as a whole."

Capabilities

Our Engineering Solution's Digital Engineering team can provide enhanced project outcomes through the creation of digitally animated video or sequence of images for:

- Displaying the construction sequence via 3D or 4D animation, enabling improved programme efficiency and collaboration throughout design and construction.
- 3D animated site fly-through, enabling improved communication with key stakeholders.
- Animated traffic management plans for business or stakeholder communication.
- Checking construction drawings against underground services to prevent clashes.
- Improved construction efficiency through the use of machine control, where a 3D model can be used with compatible plant.
- Improved environmental, health and safety, and quality performance through the use of animated video for forward work planning, and throughout construction as variations occur.

Alternative viewing options are available, including virtual reality, to immerse viewers in the project construction sequence.

Innovation in data management

Geospatial data keeps everyone on the same page

For organisations responsible for delivering significant infrastructure projects, issues with data sharing and collaboration can reduce the likelihood of delivering on-time and on-budget. International research by data experts Experian suggests more than 75% of organisations report incurring costs from 'dirty' data, while only half feel confident in the quality of their data.

The $234 million TfNSW Sydney B-line project presented an opportunity for the Fulton Hogan team to find an innovative way to mitigate against these risks.

The B-line project is a rapid double-decker bus network connecting Sydney's Northern Beaches with the Sydney CBD. Awarded to Fulton Hogan in 2016, the project generated screeds of geospatial data from teams working around the clock across 10 precincts.

NSW-based Michael Connor, regional survey manager, first championed the adoption of cloud-based 12d Synergy, an innovative piece of project collaboration and data management software, to address these data challenges.

Michael implemented the platform to customise access, manage version control, and provide remote connectivity to a centralised data source throughout the project.

He says the use of 12d Synergy has since boosted efficiency and collaboration on all of his projects, and has been an excellent way to keep clients involved, as many of them are already proficient in the platform.

"This cloud-based solution enables us to connect our project team from office to field, and keeps our clients up -to-date by providing them a live-feed of our progress on the project," he says.

The power of 12d Synergy is enhanced by 12d View, a platform that gives on-site engineers the ability to view, analyse and interrogate live information as it comes in from the project designers and surveyors.

"These platforms give our teams the ability to work from a single source of truth, and feel confident that the project's shared data is clean, current, and moving our work in the right direction."

The Sydney B-line project was an excellent pilot programme for cloud-based collaboration and data-sharing at Fulton Hogan, but still relied on storing data in local servers protected by firewalls.

The team will take the final leap into the cloud on Fulton Hogan's upcoming Nowra Bridge project in NSW, using Microsoft Azure to host data in a fully cloud-based system.

It also paved the way for the future application of cloud-based solutions. After years of development, Fulton Hogan is now on the cusp of achieving an enterprise–wide solution for managing cloud-based data. This will ensure designers, consultants, survey teams and clients can all access 'live' information in a centralised environment from anywhere in the world.

"The ability to connect everyone in our delivery teams with cloud-based data will be revolutionary for us, and for the industry. Very shortly it will be hard to remember a time when we weren't all connected via the cloud," says Michael.

Innovation in bridge building

Mission accomplished with boat-based pier building

Care for the fragile environment of the Tamaki River in East Auckland was a major factor in Fulton Hogan developing an ingenious new means of constructing pile caps. In its tender team for Auckland's AMETI Eastern Busway, the team proposed a purpose-built boat as a more environmentally sound, safer, more efficient and quicker way to build the two piers of the new Eastern Busway bridge across Tamaki River, adjacent to the existing Panmure Bridge.

The team looked for a better way than the traditional approach of installing a cofferdam. The result was a concrete-bottomed, steel-sided boat, with eight steel hatches in the floor. This was constructed on a boat ramp within the site and slid into the water. Once the boat was floated to position and hung from temporary supports, the hatches were opened at low tide, enabling the piles to be constructed through them. During piling, the boat was used as secondary containment for any lost spoil from the pile drilling.

After piling, the joint between the piles and the concrete bottom section was sealed to make a dry working environment for placing the reinforcing steel of the pile cap. The boat was then filled with concrete and, when set, the steel sides were removed and reused for the second pier.

The first pile cap, completed in the third quarter of 2019, showed that the theory worked well in practice, and the joints between the concrete base (built by Fulton Hogan) and the steel sides (made by Hornell Industries) were water-tight.

Thus the second pile cap was constructed this year, with only minor modifications to the process.

"It is extremely gratifying to see an idea that was dreamed up at tender time carried all the way through to construction," says Project Director James Weller.

"This innovative engineering solution allows us to have an environmentally safe area for piling, a dry area for constructing the pile cap below the tide levels, and temporary formwork for the pile cap already in place."

Project Engineer Alison Craigie says containing all the spoil from the excavation for the piles was a key element.

"Removing the risk of any spillage into Tamaki River was critically important. I think it's a brilliant idea that's particularly good for very deep and tidal water. The system allowed us to work at any tide."

The boat has been disassembled and, in a case of adaptive re-use, two sections have gone to Fulton Hogan subsidiary, Stahlton, to be used as pre-casting beds.

> **It is extremely gratifying to see an idea that was dreamed up at tender time carried all the way through to construction.**
>
> Project Director James Weller.

Innovation in construction

Paving the way for the future

Have you ever spared a moment's thought for how you would do airside repairs to the runways, taxiways and parking aprons at a busy international airport?

Regular Portland cement concrete can take up to 28 days to reach its full compressive strength – making quick repairs prohibitive when you need to keep things moving. Fast-set concretes have been around for a few years, but they can be hard to work with. They can't be used with standard concrete mixing, placing and handling equipment, as the workable time before the concrete is set is so short that it can set inside the equipment, leaving you with expensive equipment repairs or the need for replacement in short order.

So, while fast-setting concrete can do the job and return the pavement to service in a few hours, it requires a specialist team to work fast and get everything done before the concrete sets.

Fulton Hogan has been working with Melbourne Airport continuously for nine years and, in 2018, were contracted to replace a number of concrete slabs that had come to the end of their life.

Prior to starting, a number of fast-setting concrete products were considered. As they progressed, it became obvious that a review of all of available products was necessary. Enter Concretum – a game changing fast setting concrete product.

Swiss-engineered, Concretum is already in use at some of the world's busiest airports – Zurich, Frankfurt, Paris, Brussels, Vienna, Prague, Istanbul and London Heathrow.

To ensure Concretum would meet the demands of the project, Manager – Project Support & Completions Chris Yates met with Concretum and their customers and end users, including Zurich Airport, to better understand the product. This visit included witnessing numerous mixes both in the Concretum laboratory and on site.

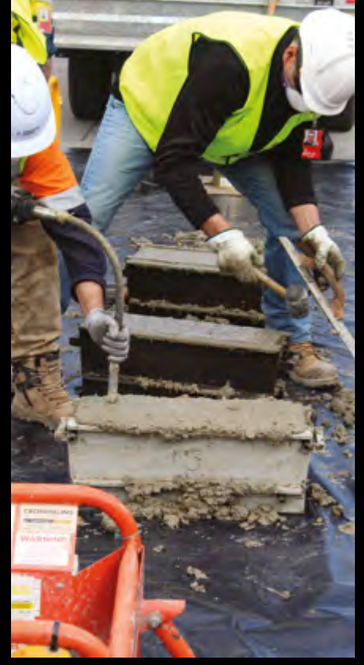
Concretum, a spin off from Zurich University, is unique because it enables us to set the open time, with an accuracy of just a few minutes, from 30 minutes to up to two and a half hours. This unique feature means that all standard concrete mixing, placing and handling equipment and techniques can be used with Concretum, including pumping! Something simply not possible with other cements.

Concretum-based concrete attains sufficient strength in just four hours after placement, to allow heavy duty pavements to be returned to service. Just a few hours after placement, an A380 (weighing 580 tonne) can be parked on it, compared with wait times of up to 28 days for regular concrete products.

Unfortunately, Covid-19 has impacted on starting to use Concretum at Melbourne Airport. The level four lockdown meant much of the work had to be put on hold.

Keen to be sure the product is fit for purpose as projects start to get up and running again, the time has been used to run tests with quarry products from New South Wales and Queensland. Variations in the characteristics of natural quarry products can affect the performance of the concrete. Fulton Hogan tailors each mix design to accommodate these variations, and ensure the quality of the concrete.

We are proud to be partnering with Concretum to bring this innovative and world class technology to the Australian and New Zealand construction industry.



Engineered for success

A perfect fix for the requirements at Melbourne Airport, the potential applications for Concretum go far beyond one project.

Fulton Hogan is in the process of acquiring the exclusive rights to Concretum for Australia and New Zealand, adding it to the innovative products offered by our new business, Engineered IQ.

While our project-based work and problem-solving skills are at the heart of our expertise, Engineered IQ seeks to expand the thinking beyond simply which concrete, asphalt or product best suits the unique circumstances.

Rather than seeing how a product fits for a specific piece of work, Engineered IQ focus on what the product can achieve in totality. It allows the business to be more agile, and see opportunities where a product may be useful, rather than just one element in a larger picture.

As well as Concretum, Fulton Hogan has added a retaining wall product called Vistawall to its roster of innovative products that Engineered IQ offers.

An end-to-end service, Vistawall assures supply and efficient installation. It streamlines the process, which can reduce risk for a project. In less than 12 months, it's been used in a number of level crossing removal projects in Victoria.

With these two products underway, Engineered IQ will continue to look for additional innovative solutions they can take from project level and elevate to become holistic solutions for the industry.

Innovation in bitumen tanker design

Quad axle burnerless bitumen trailer

Innovation in bitumen tanker design in Australia has been slow over the last 20 years, and with the advent of Performance Based Standards (PBS) nationally, there has been an opportunity to look at how Fulton Hogan can improve utilisation and efficiency of the transport tanker fleet.

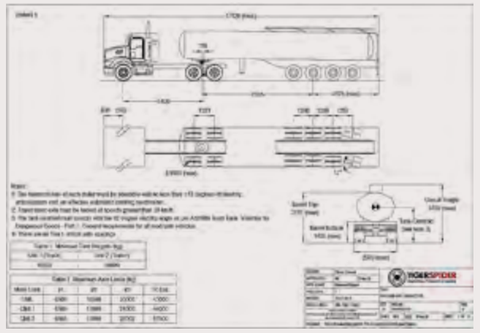
In New South Wales, the average size for a load of bitumen in a semi-trailer is currently 23 tonne, and the overall axle and gross weight laws limit capacity. By adding a fourth axle and complying with PBS Standards, there is an opportunity to lift the carrying capacity to approximately 30 tonne, a 30% increase in utilisation.

The Fulton Hogan transport management team were investigating opportunities to increase vehicle load sizes and efficiency, and decided to explore a lightweight trailer with the maximum legal carrying capacity possible for use across the eastern states of Australia.

Subsequently, the team met with trailer manufacturer Holmwood Highgate to discuss the design and manufacture of a trailer that met their design brief, resulting in a trailer design that utilised the maximum weight limits, whilst being as light as possible and still retaining all of the current build and safety features required.

Approximately 50% of bitumen volume delivered by the transport team in the region is within a one hour travel time of the loading facility, meaning it does not require reheating upon arrival at the customer site. With this in mind, it was decided that the new trailer would not include a burner or other equipment needed for such short trips. This reduces the cost and weight of the trailer, further increasing carrying capacity and efficiency.

By combining the increased carrying capacity and burnerless design, meaning less kilometres on the road (4,500 per year in fact) and no energy required to heat the bitumen Fulton Hogan Transport has saved in excess of 6,000L of fuel per year and reduced carbon emissions by nearly 17 tonne. That's the equivalent of taking seven cars off the road every year!



Without the need for a burner, pumping system or reticulation pipework, and the addition of a fourth axle and lighter construction, the trailer design gives a 30% increase in utilisation and, hence, efficiency. With a steerable rear axle and at just one metre longer than a standard trailer, manouverability is high, giving access to all current delivery points.

"This is an exciting project that will not only increase payload and efficiency, but also will free up our regular fleet to carry out our long haul commitments. By double shifting this unit, we are able to see a reduction of truck movements on site, which is also welcomed by our customers," says National Transport Manager Nick Mortimer. "With a steerable rear axle and an overall combination length increased by just one metre, this combination is very manoeuvrable, and will be able to access all of our current delivery points with ease".

To further reduce weight, a review of the specification was made to remove unnecessary mass and therefore optimise the payload.

Some key changes to the standard tanker specification:

- No pumping system or recirculation pipework.
- No heating system.
- Aluminium landing legs.
- Aluminium brake tanks.
- Optimised tank and sub-frame design.
- No tyre carrier or spare tyre.

Mark Skinner, principal engineer at Holmwood Highgate says, "As the design does not have its own heating system, small details have been considered in an effort to reduce heat loss. The number of tank surfaces that protrude through the insulation have been reduced, and any such surfaces will be painted silver to reduce the amount of radiant heat loss. Should heating ever be required, thermo wells have been installed to allow electric heating elements to be fitted".

The design stage of the trailer has now been completed, and approval has been granted for PBS design compliance. Route plans have also been submitted to the local regulator and approval has been granted, subject to supplying registration details once the unit is built and registered.

Building of the trailer has now commenced at Holmwood's Brisbane manufacturing facility. This design is a first in the bitumen industry in Australia, putting Fulton Hogan at the forefront of innovation and design.

Innovation in spreader safety

Forward thinking leads to innovative forward spreader

The asset and maintenance team in Melbourne, Victoria, has designed and custom-built a new forward moving aggregate spreader, which could significantly improve safety on worksites. This came about after the client, VicRoads, mandated forward spreaders be used from 1 July 2022.

The forward spreader concept is all about improving the safety standards in and around spray sealing sites. By operating the vehicle from the rear, as opposed to the front, operators have a better view of the work zone and surrounds, improving the safety of workers onsite.

While a number of companies chose to have the two major European forward spreader manufacturers build their machines, Fulton Hogan's divisional manager of assets and production, Phil Olsson, identified a couple of drawbacks to this. The spreaders were heavy and complicated, which could make them more prone to breaking down, and they could only be used for the sprayseal season, meaning they would be parked all winter.

Phil came up with the idea of using a standard off-the-shelf truck, fitted with a regular Trout River walking floor body, engineered and rebuilt to be steered from the rear. The Trout River walking floor body is designed and supplied locally, and one major advantage of these units is they that don't require tipping up, reducing the risk of overhead power strikes, tree contact, and roll overs. There were already Trout River body trucks working in the spray seal fleet, meaning they had a proven track record of good performance, and the team were familiar with their operation.

Phil worked with Fulton Hogan's workshop manager at Dandenong, Ken MacDonald, and specialist companies, to bring the prototype to life. They acquired a second-hand Acco Truck, extending the chassis to accommodate the body, and an additional conveyor required to feed the spreader box, allowing enough room to install a rear facing cabin above the conveyor, while also achieving the correct axle weights. The team then worked with a specialised steering company in Melbourne to integrate the rear steer system into the existing truck's hydraulic steering system.

They looked at different cab options for the rear, and repurposed a cabin from a WA470 Komatsu loader. They then integrated the additional transmission controls, lighting, and brake circuits to safely engineer the spreader to be driven from the rear.

"We now have a truck that will do what VicRoads asked for in terms of sprayseal, and in winter we can just remove the spreader box component, and still use it to cart asphalt into a paver," says Phil.

"I really do believe ours is the best design there is in the industry, set apart by the steering, braking and rear drive component. It is fully integrated and engineered into the truck system."

Innovation in reinforced earth embankments

A basket full of innovation at the Eton Range

Inland from Australia's North Queensland coast sits the Peak Downs Highway, a vital link across the Eton Range – part of Australia's Great Dividing Range.

Around 35km southwest of Mackay, the Eton Range Realignment Project (ERRP) presented a challenge, and opportunity, for Fulton Hogan to find an outside the box method to construct a reinforced earth embankment (REE) in challenging geotechnical conditions and in a tropical climate. The result – the Southern Hemisphere's largest application of the Maccaferri Green Terramesh® system, across a 780m long REE that reaches 45m high at its highest point.

Fulton Hogan worked closely with the client, Queensland Government Department of Transport and Main Roads, to upgrade the existing range crossing to four lanes, and to deliver a split dual carriageway for part of the range to reduce the grade and improve safety and efficiency on this key mining and agricultural transport route.

The client's original business case design for the REE relied on the use of around 400 temporary pre-cast concrete units to facilitate compaction of the external face of the REE batters.

Given the steep terrain, long-term facial instability for the REE was significant, and without the right solution it could potentially lead to future operational and maintenance issues. As an alternative slope stabilisation and landscaping solution, Fulton Hogan proposed using the Maccaferri Green Terramesh® system. This created a singular structure that retains a suitable growing medium on a 45 degree batter, providing a long-term solution to manage the risk associated with landslips in a tropical climate.

Green Terramesh® is a third-party product supplied by Geofabrics Australasia. The system has a welded mesh panel to reinforce the front basket face, with a 2m tail section. It incorporates a biodegradable coir coconut fibre matting inside the front face for erosion control. The basket also holds landscaping media, providing a grip layer for the organic blanket seeding, enabling root systems to grow and gain a secure hold on the substrate beneath. Each Green Terramesh® basket was installed at a 51 degree angle, with a 600mm step every three metres. At its deepest point, the REE has 54 baskets in height.

Given how critical it is to establish vegetation to protect the REE from erosion, the presence of widespread presence of declared noxious weeds and poor site subsoils required advanced topsoil management and a substantial amelioration program to turn site-won material into suitable growth media. A sophisticated irrigation system with large water tanks connected to gravity-fed pipework was used to ensure the successful and progressive growth of the vegetation as the REE was built.

The landscaping process was a collaborative effort, and the final solutions were delivered in collaboration between Fulton Hogan, the client, and specialist subcontractors Lanyonscapes and Hortus.

Fulton Hogan's work in the Eton Range was acknowledged at the 2019 International Erosion Control Association (IECA) annual awards, when the project team received the Environmental Excellence Award for its novel approach to this complex project.

This outside the box thinking has set a new benchmark for other topographically challenging projects in Australia.

Innovation in water management

Sustaining life – Waimea Community Dam

In early 2022, the first of the 13 billion litres of water will enter the reservoir of Waimea Community Dam. This image shows the reservoir, with the dam to be built on the far left. Around 30km south west of Nelson, Waimea Community Dam is the first major dam project in New Zealand in 25 years – and the largest dam built in New Zealand in 40 years. Fulton Hogan and Taylors Contracting are building it for Tasman District Council and Waimea Irrigators Ltd to irrigate the fruit, vegetables, hops and grapes of the Waimea Plains, alleviating the effect of crippling droughts in recent years.

The benefits include:

- Meeting the region's water supply needs for the next 100+ years.
- Improving water quality and providing a better environment for people, plants, fish and animals.
- Strengthening primary industries and associated secondary and tertiary industries, bringing economic benefit to the region estimated to be $900 million by 2040.

The project features construction techniques and technologies not used in New Zealand before, many developed in China and South America, the hot house of dam building in recent years.

Slipforming

Encasing the dam embankment's upstream face will be a 300mm thick concrete slab, applied on the 1:1.5 slope using the 'slipforming' technique. Developed in South America and being used for the first time in New Zealand on this scale, it involves two 40 tonne winches pulling a 15m wide platform up the dam face. The concrete face will require 12 slip-formed slabs, 15m wide and up to 80m in length.

Due to the steep incline and high quality concrete required, the slipformer will be winched at a rate of 2.5m/hr – one slab taking more than 30 continuous hours to produce, with multiple crews working around-the-clock over two months.

Slipforming is also being used to concrete the base of the spillway, which is inclined at the main chute at up to 30 degrees. A different type of slip-former will achieve the high quality, mirror-like finish necessary to enable water to spill at near laminar flow, minimising the likelihood of cavitation and, therefore, stresses on the spillway.

Concrete specification

Other recent developments, including the failure of the Oroville Dam spillway in California in 2017, have accelerated techniques for maximising adherence to underlying rock, and the quality of spillway concrete finishes.

"Building a dam requires higher specifications for the concrete material product, placement methods, finish and curing than almost any other structure – the forces of water are the greatest we deal with," says Fulton Hogan Waimea Dam Structures Manager Matt Loach.

"The spillway, in particular, is hydraulically critical, any imperfection can create the potential for it to self-destruct from cavitation during a spilling event."

Given the safety requirement of a dam doesn't diminish with age, there's been careful thermal finite analysis modelling on the dam – virtual experimentation to optimise designs of the concrete, as well as in-situ concrete trials to minimise the potential for micro-cracking.

This helps determine, for example, the likely temperature at one point in the concrete in relation to other points, over time, as it sets.

The concrete mix designs have particularly low water cement ratios (0.4), which increases the cement content and adversely affects the temperature and workability of the mix.

The mixes are required to be air entrained in the order of 5%. Air entrainment is the intentional addition of small air bubbles into the cement paste, to reduce the internal stresses caused by the freeze/thaw cycle. This is a fine balance between removing entrapped air, without removing the required entrained air during placement and compaction. The greater the volume of air in concrete, the weaker it is, and thus the greater the cement content required to achieve desired compressive strengths.

The project specification also requires that peak (maximum concrete temperature) and differential (difference between the core and surface of the concrete) temperatures be kept low.

The concrete has high levels of fly ash - in the range of 30-50% - that substitutes for the equivalent amount of Portland cement. Fly ash, a residue from coal-fired electricity generation, creates a secondary process to the normal calcium hydroxide reaction within the concrete. This helps flatten the temperature/time curve and minimise potential for micro cracking.

Adherence

A key challenge has been ensuring water tightness on rock that is naturally highly foliated (fissured) rock. A series of stable grout mixes have been injected up to 30m into the ground along the upstream perimeter of the dam, and the base foundation rock painstakingly hand cleaned at a rate of 1m² per person per hour.

"With so many people working on their hands and knees it had all the appearances of an archaeological dig," says Matt.

Crane technology

For a dam that will have around 450,000cm³ of rock in its core, be 180m wide at the base, 6m wide at the crest, 55m high, 220m long at the top, and 80m at the base, the project needs special equipment. This includes one of the largest excavators available – a 90 tonne Hitachi 890 – and New Zealand's first Tadano 120 tonne telescopic crawler GTC-1200 crane.

Matt says the Tadano has been invaluable.

"The site is essentially a large mine, and the steep access roads are a real challenge for any lattice boom crane, and the tight crane pads are often too tight for an all-terrain crane. The ability to retract the boom and track width on the Tadano, whilst maintaining full counterweight, has been key.

"The repetitive establishment and disestablishment of work areas would be far too slow with a lattice boom crane. The ability for the Tadano to be parked on a steep grade with a small footprint with boom and tracks retracted enables a quick change-over between the structures and earthworks teams."

Key Design Parameters

EARTHQUAKE

- Operating basis: No non-superficial damage and fully operational: 1:150 AEP (years).
- Seismic evaluation basis: Retain reservoir contents: 1:10,000 AEP (years).
- GNS seismic assessment: 0.64g horizontal peak & 1.65g maximum spectral accelerations.
- Active faults 8km and 12km from site.

FLOOD

- Probable maximum flood (PMF): 1,094m³/s (18.6 million m³/24 hour).
- 100 year flood: 375m³/s.
- 12 May 2019 1:50 year 250m³/s (47mm/hr).

OPERATIONAL FLOW

- Operational flow: 2.2m³/s.
- Environmental (min) flow and flushing flow: 0.5m³/s and 5m³/s.
- Maximum: 17m³/s (1.5 million m³/d = 10% reservoir/day).

The water level in the completed dam will be just below where the pine trees to the right of the picture have been felled. The dam structure is on the far left, to its right are some of the sediment retention ponds that capture and treat all run-off from the site to prevent it entering the Lee River. The rock piled further to the right on the elevated area is some of the 430,000m³ of rock that will be used in the core of the dam.

Innovation in scanning and bulk data collection

Scanning helps revolutionise dam building

Understanding exactly what's in the ground at the base of Waimea Community Dam is critical to the integrity of a structure that will retain 13 billion litres of water. This is one of the reasons the Fulton Hogan/Taylors Contracting joint venture, on behalf of Waimea Water Limited, is making extensive use of high-speed 3D scanning, 3D machine-controlled equipment and GPS survey solutions.

Understanding and acting on its potential is part of Fulton Hogan's Site of the Future® philosophy, in which the company takes learnings from key sites to other projects.

Quality Engineer Reece Moon says a major challenge has been gaining an accurate, holistic survey view of an access-challenged site.

"We needed a way to track progress and compare slopes, compaction conditions, and to address issues as they arose, mindful that the dam surface is so steep that it would be impossible to manually verify progress and assess compaction or slope accuracy," says Reece.

"The other possible approach, drones, would lack the necessary accuracy on such steep slopes."

This technology has provided the answer, directly boosting survey productivity, accuracy and efficiency. This includes an estimated 90% less time in survey mapping highly fractured and foliated rock at the base of the dam structure.

Given the importance of the structure it supports, the most critical need is to locate geological features and defects. Reece says the Trimble SX10 Scanning Total Station for as-built surveying, imaging and high-speed 3D scanning is the most valuable piece of new technology on the site.

"It's fast, the data is accurate, and it's immediate. It has already provided a variety of tangible quality, costing and design outputs, including the ability to tailor ground anchor lengths to specific geological features and reforecasting volumes to a high level of precision," says Reece.

The Trimble SX10 provides a detailed foundation map that accounts for all geological realities, including localised features in rock up to three metres deep, and alluvial seams.

The image below shows an output of the technology, a master foundation as-built - a collection of colourised scans spliced together.

When coupled with the project survey model as shown below, the team can immediately see the relationship between as-dug conditions and the dam structure, within millimetres. This instantaneous ability to review on-the-ground conditions and design has proven critical to apply a solution-based approach to unforeseen issues in a time critical environment.

Reece says not only has the technology been used to improve the end product, it also has also played a pivotal role in investigatory/temporary works, and in their implementation. The team use scanning data comparisons to tailor and improve efficiencies of designs, which pass through to a series of 3D guided equipment on bulldozers, excavators, rock breakers, rock saws and drill rigs.

"With the success of the technology and, in tandem with the various other surveying and construction equipment, the team is continuously finding benefits in its use, and foreseeing further developments," says Reece.

"On the horizon, and currently being trialled, is utilising on-the-ground augmented reality systems to highlight areas requiring scanning and further investigation."

Innovation in robotics

Tiny Surveyor takes line marking in its stride

Tiny Surveyor is a robotic platform that provides safer, faster and more efficient setting out of line marking, and allows surveyors to work from their vehicles or in a delineated area, away from traffic or plant. Fulton Hogan has been an early adopter of this technology, and the potential uses of the robot are growing.

The marking design is uploaded to Tiny Surveyor via USB, and controlled by a surveyor using a tablet. The standard arrangement has a spray can loaded into the robot, which is then computer guided where to move and where to spray. The tablet sends jobs directly from the USB to the robot.

Fulton Hogan recently used Tiny Surveyor for the line marking at the Pignata Road carpool facility in Palmview, Queensland, for 240 vehicles. Normally taking 7.5 man hours, Tiny Surveyor completed this in just 1.5 hours – five times faster than a surveyor using a GPS/GNSS (Global Navigation Satellite System) pole-mounted rover.

Tiny Surveyor also delivered savings on the Deans Avenue car park project in Christchurch, recently completed by Fulton Hogan for the Canterbury District Health Board. The job had more than 360 car parks to set out, along with all the lane and give way lines. As well as reducing the survey time from 10 hours to three, and Tiny Surveyor completing all the intermediate marking as it went, there was no need for string lining. This saved a further half day for the line-marking crew.

Tiny Surveyor also provides safety benefits on busy sites or live roads, because the surveyor can control the setting out from the safety of a shadow vehicle.

Tiny Surveyor integrates with Fulton Hogan's existing GPS/GNSS equipment and survey software. Product developments will allow it to be connected with the total station for height measurements and topographical surveys, as well as staking out at GNSS restricted areas. This will allow Tiny Surveyor to be used indoors or in central city areas, where satellite visibility is restricted.

Reducing the survey time from 10 hours to three. There was no need for string lining, saving a further half day for the line-marking crew.

Innovation in shoulder compaction

An edge in safety for shoulder compaction

With nearly 250,000m³ of bulk fill compaction along the shores of the Otago Harbour, the Portobello Road team is welcoming New Zealand's first construction roller with a factory-built twin plate compactor attached to the back.

The German-made Hamm H13i is the first of its type in New Zealand. It increases operator safety along the shoulder, while boosting productivity by construction rolling and shoulder compacting simultaneously.

The plate compactors slide 800mm outside the roller's wheelbase to the left and right of the machine, allowing the operator to keep a safe distance from the shoulder. The plates can be detached on a quick hitch system in a couple of minutes when they're not required. The same goes for the pad's foot (sheep's foot) shells on the drum, which can also be removed to utilise the roller for the pavement construction

"In the past we've been using modified equipment as well as rolling near the shoulder using traditional rollers - not a practice we endorse," says South Island Contracting Operations Manager Tony Thompson.

"These unsafe practises have put our people at risk of serious harm in the past, especially if a driver is distracted and/or if there is a soft or uneven shoulder. The business has been working on solutions to address this risk for some time, so this roller has been a great solution."

Project Manager Jamie Ward-Allen says early feedback from operators has been encouraging.

"It's packing the material right to the edge of the plates, and the operators are liking being a comfortable distance from the shoulder," says Jamie.

A 'guide bar' at the front of the roller helps ensure they don't travel closer than a metre from the shoulder.

Recently, Fulton Hogan purchased a Stehr SHV 160B compactor for shoulder compaction. Tony says these do a good job, but it's an advantage to roll the main carriageway and compact the shoulders at the same time with one machine. One benefit of the Stehr compactor is the ability to compact over the hinge point of the shoulder, and still keep the loader in a safe position on the road.

Portobello Road is being widened to create space for pedestrians and cyclists, and is a key tourist route to the head of the peninsula and the famed albatross colony.

Key elements are bulk fill, hand-stacked rock sea walling, raising the road level to future proof against sea level rise, road widening from 6.5m to 11m, drainage improvements, surfacing works, line marking, pump station upgrades, installation of kerb blocks for a separate shared path, and landscaping and pavements.

Stehr SHV 160B at Christchurch Northern Corridor (CNC).

Hamm H13i at Portobello Road, Otago Harbour.

You can’t solve a problem on the same level that it was created.

You have to rise above it to the next level.

Albert Einstein.

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