NACOE

NATIONAL
ASSET CENTRE
OF EXCELLENCE

ANNUAL HIGHLIGHTS REPORT

2019 – 2020

AN INITIATIVE BY: arrb | Queensland Government

CONTENTS

FOREWORD BY NACOE BOARD

Welcome to the Annual Report for the National Asset Centre of Excellence (NACOE).

We deliver engineering excellence through leading road asset research that welcomes innovation and drives road management practice efficiency, creating fit-for-purpose engineering solutions.

We would like to take this opportunity to reflect upon the continued commitment between the Department of Transport and Main Roads (TMR) and the Australian Road Research Board (ARRB) in delivering cost-effective, safe, and practical solutions to Queensland road users through the NACOE Program.

Throughout this report we showcase our many shared achievements, despite an incredibly challenging year due to the COVID-19 pandemic. Our research continues to promote more sustainable and resilient infrastructure for the future transport network.

With an unprecedented turn of events due to the pandemic, our people and industry partners were introduced to a new way of working. One thing that did not change was our ability to remain strong as a team as we transitioned into a working from home environment to deliver the program of works.

We are committed to driving positive change in our sector by providing sustainable solutions for Queensland and to help deliver on its vision to become a sustainable, low-waste, circular economy. We have progressed our research into assessing the lifecycle benefits and Greenhouse Gas Emissions reductions of using innovative pavement solutions which will help increase the uptake of recycled materials in pavement construction by the industry (pg. 18).

NACOE and TMR had the pleasure of collaborating with our amazing industry partners to deliver some exciting project outcomes, including the: Australian Asphalt and Pavement Association, Queensland University of Technology (QUT), Logan City Council, Main Roads Western Australia (MRWA) and the Western Australian Road Research Innovation Program (WARRIP). Through these partnerships we have:

- Collaborated with WARRIP on developing a Sustainability Assessment Tool to calculate the economic and environmental sustainability benefits of innovative pavement design options that will contribute to Queensland's waste reduction (pg. 64).
- Developed a pilot project-specific technical specification for the use of Intelligent Compaction which was successfully trialled on the Ipswich Motorway Upgrade Stage One (Rocklea to Darra) project (pg. 22).
- Developed a new specification for Recycled Crush Glass (RCG) which specifies the requirements for the use of RCG in asphalt and unbound granular applications (pg. 23).
- Conducted a full-scale pavement trial in collaboration with Logan City Council at Logan Street near Eagleby QLD, to evaluate the effectiveness of geogrid reinforcement in flexible pavements under real pavement conditions (pg. 18).

Looking to the future, we will continue to work together with our stakeholders and delivery partners to implement research outcomes, share knowledge nationally and drive savings that benefit the Queensland community and beyond.

Thank you everyone who played a key role in delivering these mutually beneficial outcomes. We hope you enjoy reading the rest of the highlights featured in this report.

Amanda Yeates
Chair (TMR)

Dennis Walsh
TMR

Matthew Bereni
ARRB

Richard Yeo
ARRB

OUR MISSION

Since 2013, NACOE has driven savings and enhanced national technical capability in transport and road asset engineering through:

- UNLOCKING INNOVATION
- IMPLEMENTING INTERNATIONAL BEST PRACTICE
- TRANSLATING NEW KNOWLEDGE INTO PRACTICE

STRATEGIC OBJECTIVES

DEVELOPMENT

Developing the capabilities of staff and disseminating learnings to TMR regions and industry.

COST SAVINGS

Delivering economic benefits to the Queensland network through cost-effective innovation and higher performing pavements, refined asset management practices, efficient management of structures and optimising road safety and network operation outcomes.

COLLABORATION

Working in partnership with industry, universities, and government bodies to leverage research and resources, helping to deliver mutually beneficial outcomes.

IMPLEMENTATION

Facilitating demonstration projects, establishing research tools and infrastructure to help implement new technologies and practices in Queensland.

ACKNOWLEDGEMENT

We would like to acknowledge our partners, the Queensland Department of Transport and Main Roads (TMR) and the Australian Road Research Board (ARRB) for their collaboration on the development of the NACOE Program since its inception in 2013.

We would also like to thank and acknowledge the organisations, universities and industry associations who collaborated on NACOE projects, of whom without their valued support and input, much of the road research work we do, would not be possible.

ABOUT OUR PARTNERS:

Queensland Department of Transport and Main Roads (TMR)

The Department of Transport and Main Roads (TMR) moves and connects people, places, goods, and services safely, efficiently, and effectively across Queensland. They plan, manage, and deliver Queensland's integrated transport environment to achieve sustainable transport solutions for road, rail, air, and sea.

TMR's vision is to create a single integrated transport network accessible to everyone. The integrated transport planning approach ensures TMR contributes to people's quality of life, Queensland's economic wellbeing, and a sustainable environment.

Australian Road Research Board (ARRB)

ARRB was founded in 1960 and is the source of independent expert transport knowledge, advising key decision makers on our nation's most important challenges. ARRB has a strong heritage of supporting and delivering high quality applied research for Australian and New Zealand state road agency members and for the community. ARRB's vision is to help make the world's cities smarter, cleaner, greener, safer, more efficient, and productive through intelligent transport solutions.

COLLABORATION AND DISSEMINATION OF LEARNINGS

Collaboration with industry, universities, and government bodies are one of the key strategic objectives for NACOE. The NACOE Board believes ongoing collaboration will allow the Department to leverage off research and resources from other organisations, which in turn will deliver mutually beneficial outcomes to everyone involved. In 2019-20, NACOE worked with multiple external organisations, including:

- The Queensland Department of Environment and Science – to develop technical guidelines and specifications for the use of recycled tyres and glass.
- Local Government Association of Queensland – to develop Local Government Heavy Vehicle Route Assessment Guidelines.
- Central Queensland University – to develop an objective, automated method, and software for identifying roadside objects and road design features for road safety assessment.
- The Queensland University of Technology – to quantify the benefit of geosynthetics for the mechanical stabilisation of subgrade materials and develop guidelines for pavement design.
- The Western Australia Road Research and Innovation Program (WARRIP) on multiple collaborative research projects.
- Tyre Stewardship Australia – facilitating the use of recycled tyres in Queensland.
- Logan City Council – investigating the benefits of subgrade reinforcement using geosynthetic layers and implementation of intelligent construction on local roads.
- City of Gold Coast – implementation of crumb rubber modified gap graded asphalt.
- AAPA – the implementation of Intelligent Compaction technology into Queensland, as well as the development of a new specification for crumb rubber modified gap graded asphalt.
- City of Gold Coast – implementation of crumb rubber modified gap graded asphalt
- The Transtec Group Inc. – collaboration on the first industry workshop held in Queensland on Intelligent Compaction Data Management (ICDM) 2019.

It is believed these collaborations are one of the key success factors of the NACOE research program and will continue in future years. Another important strategic objective of NACOE is ongoing development through the dissemination of learnings to industry and the regions.

To further enhance national knowledge dissemination, NACOE research has been prepared for presentation at ARRB's inaugural Smart Pavements Now masterclass event (September 2019).

Smart Pavements Now is a three-day event, showcasing the latest trends, emerging issues, and best practice in all aspects of pavements, facilitating hands on learning in a highly interactive environment.

BENEFITS OF NACOE

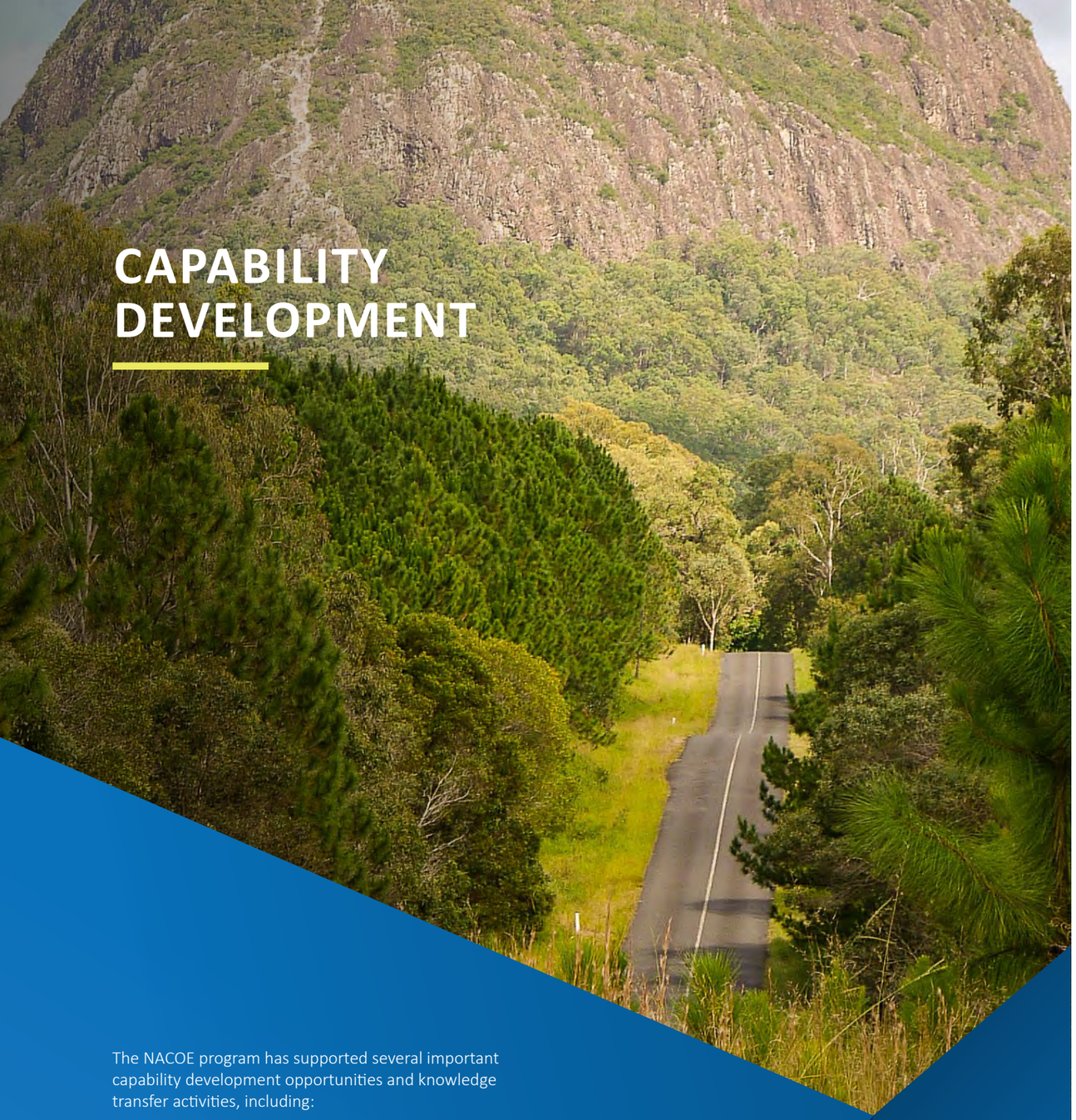
NACOE is continuing to deliver strong economic and sustainability benefits to the Queensland Department of Transport and Main Roads (TMR) and broader Queensland community. The program has delivered many high value research projects since it started in 2013. Some of the key benefits of NACOE to-date include to inform:

- Upgrading department specifications, based on the review of world's best practice and laboratory research
- Increased use of recycled materials in bituminous products across the network to deliver environmental benefits and enhanced sustainability
- Progressed our investigation into Intelligent Compaction and its potential role in future road construction
- Streamlined the use of recycled material and recycled material blends for unbound granular pavement layers
- Leading the way in the use of high percentages of recycled asphalt pavements and increased use of recycled vehicle tyres in sprayed seals and asphalt
- Delivered a pilot specification for Crumb Rubber Modified Open Graded and Gap Graded Asphalt
- A significant reduction in the thickness of heavy-duty asphalt pavements that has led to savings in construction costs, time, and material, resulting in sustainability benefits to the community
- Whole of life cycle cost-based approach to assessing pavement impacts from heavy vehicles
- Improved asset management practices to reduce ongoing agency and road user costs, resulting in whole-of-life transport solutions
- Enhanced risk management practices for the planning, design, and maintenance of transport infrastructure
- Guidance to the department on helping reduce crash risks on Queensland roads
- Lifecycle costing of asset management strategies to improve resilience of the network against increasing climatic threats and flood events
- Driven cost savings in design, construction, and maintenance across the network
- Improved bridge monitoring and heavy vehicle access using advanced systems
- Adopting the world's best practice in asset and risk management and fit-for-purpose solutions to structural issues
- Introduction of advanced materials and technologies into structures across the network
- Improved technical capability and knowledge of staff.

AWARDS AND ACHIEVEMENTS

- Collaborated with WARRIP on developing a Sustainability Assessment Tool to calculate the economic and environmental sustainability benefits of innovative pavement design options that will contribute to Queensland's waste reduction targets
- Developed a pilot project-specific technical specification for the use of Intelligent Compaction in Queensland
- Three research papers detailing the study process and findings of project R54: Automating Road Data Collection for Road Condition Monitoring and Road Safety Improvement have been presented and published in conferences and a symposium
- A new specification for Recycled Crush Glass (RCG) was developed which specifies the requirements for the use of RCG in asphalt and unbound granular applications (MRTS36 Recycled Glass Aggregate was compiled)
- Conducted a full-scale pavement trial in collaboration with Logan City Council to evaluate the effectiveness of geogrid reinforcement in flexible pavements under real pavement conditions
- Collaboration with Logan City Council to implement IC technology on local roads.

Geogrid reinforcement trial with Logan City Council
Image Source: NACOE.



CAPABILITY DEVELOPMENT

The NACOE program has supported several important capability development opportunities and knowledge transfer activities, including:

- Four webinars published and available on the NACOE website
- Improved technical capabilities and knowledge of staff in the use of advanced assessment technologies and instrumentation of structures
- Input into TMR training and learning platform in strategic asset management to be used for a broad range of stakeholders
- A series of customised information sessions (webinars) for TMR staff to increase awareness and application of best practice technical and asset management solutions
- 21 reports, presentations, and papers from 2019/2020 available on the NACOE website.

NACOE RESEARCH PROGRAM IMPLEMENTATION

The outputs of the NACOE research program are implemented by TMR, including but not limited to:

- the development of technical notes and design guidelines
- the development of new technical specifications
- implementation through demonstration projects
- the dissemination of learnings through presentations, seminars, and webinars
- the preparation and presentation of technical papers and industry events
- validating existing practice through data gathering and analysis.

TMR is a member of Austroads, which undertakes research to develop nationally consistent guidelines. The work of NACOE and Austroads is often complementary to each other, whereby NACOE research further develops the Austroads findings to ensure that Queensland conditions and materials are fully considered and implemented. In many instances, the outputs from NACOE research have been fed through the various Austroads task forces and working groups, which then be incorporated into national documents.

In some instances, an explorative study (typically comprising of a desktop study only) is undertaken to better understand the research need, benefits, or application prior to progressing with a more in-depth study. Where there is confidence in achieving a positive result, a follow-on project is often initiated.

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PAVEMENTS

PAVEMENTS

The Pavements subprogram represents the largest proportion of the NACOE program, with a significant number of the total projects and approximately half the total investment. This program is focused on introducing innovation and delivering engineering best practice across:

- asphalt
- road surfacing's
- unbound granular, recycled material blends and marginal materials
- stabilised/modified pavements
- Intelligent construction and new quality control technologies
- several sustainability and innovative technology projects (including alternatives to traditional pavement materials).

The findings and recommendations implemented from this research have the potential to deliver significant cost savings to Queensland and the wider Australian community and create more opportunities for further road projects to be constructed.

The major outcomes from the NACOE pavements program to date include:

- informing TMR's specifications to enable reduced depth of asphalt structural layers through the adoption of EME (Enrobé à Module Élevé) high modulus pavement
- informing TMR's design procedures to enable refinement of thickness design based on improved asphalt pavement design procedures
- facilitating the use of asphalt mixes including recycled content (crumb rubber modified binders and recycled crushed glass aggregates)
- improved understanding of the full implications of using non-standard and/or marginal granular materials through performance validation and evaluation guidelines. These pavements are widely used in western Queensland, due to non-availability of conforming materials. While they offer significant savings, they can involve increased risk of poor performance, so these risks need to be understood
- knowledge toward upgrading of many department specifications, based on the review of world's best practice, and laboratory research
- streamlined use of recycled material and recycled material blends for unbound granular pavement layers
- knowledge toward increased use of recycled materials in bituminous products across the network, to deliver environmental benefits and enhanced sustainability.

The program also has a strong focus to collaborate with industry and universities.

TRANSFERRING CRUMB RUBBER MODIFIED GAP-GRADED ASPHALT TECHNOLOGY TO QUEENSLAND

International studies have shown that crumb rubber modified gap-graded asphalt (CRM GGA) can provide increased crack resistance compared to conventional asphalt mixes. This superior performance, together with the sustainability benefits of using re-using end-of-life tyres makes CRM GGA an ideal surfacing when overlaying or rehabilitating existing cracked pavements.

A previous NACOE project 'Transfer of Crumb Rubber Modified Gap graded Asphalt Technology to Queensland and Western Australia' (Grobler 2021) developed a new pilot technical specification for the manufacture and placement of CRMA GGA mixes in Australia.
This specification was primarily based on the CRM binder requirements adopted by the Arizona Department of Transportation and the asphalt mix design requirements used by the State of California in the USA, but with some modifications to reflect local materials and construction practices.

Although the specification was successfully trialled on demonstration projects in Queensland and Western Australia, there were concerns the locally produced CRM binders may not necessarily achieve the same level of performance as the binders used in the USA. Given the local modifications made to the binder specification, the purpose of the second year of this multi-year project was to benchmark the performance of locally produced CRM binder against the binders being produced in the USA and further improve on the technical binder and asphalt specifications previously developed to optimise the performance of locally manufactured CRM GGA.

Year Two focused on assessing the laboratory performance of three locally produced commercial CRM binders and two binders sourced from California. The performance-related binder properties determined as part of the study showed that the Australian binders and Californian binders containing similar rubber contents exhibited comparable performance. In addition, the asphalt performance tests undertaken using these binders also showed comparable laboratory performance at similar rubber contents.

Based on the findings to date, it does not appear to be necessary to tighten the binder specification requirements to be more consistent with the Caltrans specification with regards to particle size distribution of the rubber particles, requirements for a minimum natural rubber content or the use of combining oils.

It was recommended that locally manufactured CRM GGA be monitored during the implementation phase to assess the performance of these mixes in-service, as well as investigate the difference in viscosity test methods (i.e., Brookfield vs. handheld device) particularly for the purpose of quality control testing during construction.

Future works of this project will include:

1. Providing technical support to another demonstration project using CRM GGA.
2. Characterise the laboratory performance (rutting, modulus, and fatigue) of an additional CRM GGA mix used in a demonstration project.
3. Undertake further development work to facilitate the implementation of an on-site viscosity test using a handheld viscometer.
4. Propose amendments to TMR's technical specification (PSTS112) for CRM GGA (where appropriate).

Finished crumb rubber modified gap graded asphalt surface
Image Source: ARRB

QUANTIFYING THE BENEFITS OF GEOSYNTHETICS FOR THE MECHANICAL STABILISATION OF SUBGRADE SOILS

A significant proportion of the Queensland Road network is constructed over natural soils subject to moisture-induced strength loss and volumetric change.

This is a significant problem, particularly in the large part of the state where expansive clays are the dominant subgrade type. International research in the USA and Europe suggested that geosynthetics offer the potential to reduce granular pavement thicknesses, which can lead to cost reduction and sustainability benefits.

The purpose of this multiple-year project was to assess whether the use of geosynthetics can lead to reductions in granular pavement thicknesses. This was achieved using field trials and laboratory testing conducted in conjunction with the industry, the Queensland University of Technology, and the Logan City Council.

A literature review of international trials was conducted in Year One which showed that subgrade stabilisation using geosynthetics may lead to increased performance of pavements.

As an interim measure, it was proposed that mechanical stabilisation of low-strength subgrades with geosynthetics could be considered in a trial by TMR.

However, before this approach could be implemented, suitable test methods to assess the effectiveness of stabilisation using geosynthetics had to be identified through experimental work.

The second year of the project focused on the identification of potential field tests such as in situ CBR, static plate load testing and Light Falling Weight Deflectometer (LFWD) testing to evaluate the effectiveness of geosynthetics in pavements. Laboratory tests were conducted at the Queensland University of Technology (QUT) to investigate the permanent-vertical-deformation behaviour of geogrid-reinforced-unpaved pavements. This involved the cycling loading on unreinforced and geogrid-reinforced pavement models using a small-scale circular mould (300 mm diameter cylindrical sample) and a large-scale laboratory-pavement-models completed in 2020.

Year Three consisted of conducting a full-scale pavement trial in collaboration with Logan City Council at Logan Street near Eagleby QLD, to evaluate the effectiveness of geogrid reinforcement in flexible pavements under real pavement conditions. The research findings will be incorporated into Year Four of the project during a field trial on a TMR road.

The anticipated benefits of this project will result in construction and maintenance cost savings through reduced thickness needed for the base that also extends the service life of the pavement. Future work will involve drafting a Technical Note on the design and specification of geosynthetic subgrade reinforcement and continue to monitor the performance of the trial section.

Image Source: NACOE

Pavement without geogrid

Pavement with geogrid

CHARACTERISING NON-STANDARD MATERIALS USING TEXAS TRIAXIAL TEST

Economic and environmental considerations encourage the use of locally available, non-standard materials as a sustainable solution for the provision of granular pavements. Some 20,000km of the state-controlled road network are composed of unbound granular pavement layers.

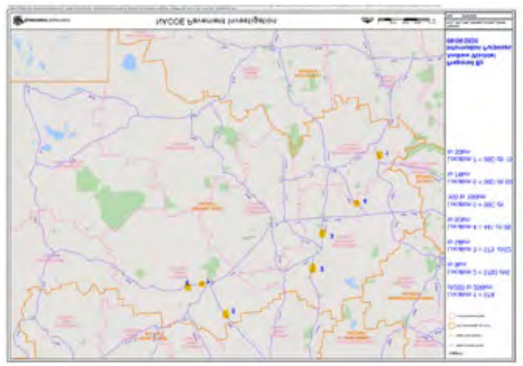
Non-standard materials typically don't conform to specification requirements however, they can provide satisfactory performance when properly managed.

Currently, there is not a universally accepted test method to evaluate the performance of these materials and previous NACOE work has not been able to identify a candidate test that consistently ranks the performance of these materials.

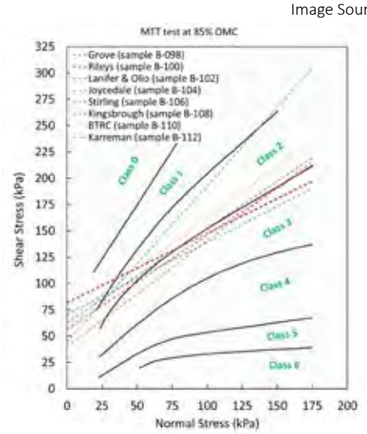
However, the Queensland Department of Transport and Main Roads (TMR) recently completed some exploratory testing on non-standard materials using the modified Texas triaxial test, which showed some promise.
The objective of this project was to assess the suitability of the modified Texas triaxial test for the characterisation of non-standard materials.

To accomplish this, seven non-standard materials sampled from road networks in central Queensland, in addition to one conforming material, were selected to investigate the characterisation of non-standard materials using a laboratory testing program. The laboratory testing program included the particle size distribution, Atterberg limits, soaked and unsoaked California bearing ratio (CBR), wheel-tracking test, and modified Texas triaxial test. The laboratory test results, including modified Texas triaxial classifications, were then compared against the known field performance and benchmarked against the conforming standard sample to analyse the ability of each experiment in predicting the behaviour of these materials in a pavement structure.

Results showed that the MTT test confirmed a generally satisfactory outcome by showing acceptable conformity with the field performance, particularly in wet conditions. However, it was found that the MTT test should be accompanied by other experiments to ensure the improved characterisation of the non-standard materials. The California bearing ratio (CBR) test is suggested to be used in conjunction with the MTT test, accompanied by the initial qualitative assessments from the basic material properties, and good engineering judgement, can result in an improved prediction of likely in-service performance of non-standard materials in a pavement structure.



Location of the selected non-standard materials
Image Source: NACOE



MTT test result of the tested materials at 85% OMC
Image Source: NACOE

ASSESSING THE LIFECYCLE BENEFITS AND GREENHOUSE GAS EMMISSIONS REDUCTIONS OF INNOVATIVE PAVEMENT SOLUTIONS IN QUEENSLAND

The NACOE program continues to develop innovative pavement research and technologies to support the Queensland Department of Transport and Main Roads (TMR) goal to reduce its greenhouse gas emissions.

In the first year of this project, five innovative pavement technologies were assessed for their greenhouse gas reductions over the pavement lifecycle and compared to a conventional pavement designs. During this initial project, it was assumed that the construction and maintenance efforts for each of the pavement designs (i.e., the innovative technologies and the comparable base case) were the same. Therefore, for comparison purposes, the actual GHG emissions from these activities were not included in the assessment.

In 2019/20, this project was reimagined to build on the development of the Sustainability Assessment Tool (SAT), under NACOE project P117 Sustainability Assessment Tool – Technical Development Report (Hall et al. 2021).

The Sustainability Assessment Tool has been developed to undertake a full life cycle assessment including construction and maintenance effort for each pavement technology. This refined methodology provides a more comprehensive lifecycle assessment of the total emissions.

Using the SAT, the 2019/20 project investigated case studies assessments of both urban and rural pavement designs to evaluate sustainability benefits of innovative technologies and materials. The case studies included:

- high modulus asphalt (EME2)
- crumb-rubber modified binder for sprayed seals
- crumb-rubber modified (open-graded) asphalt
- foam bitumen stabilised base with a sprayed seal
- dense-graded asphalt with reclaimed asphalt pavement
- marginal and non-standard material with a sprayed seal
- dense-graded warm-mix asphalt
- recycled crushed concrete in a in dense-graded asphalt
- recycled crushed glass in a standard granular base and in dense-graded asphalt
- warm-mix asphalt and reclaimed asphalt pavement combined in a dense-graded asphalt design
- recycled crushed glass combined with reclaimed asphalt pavement in a dense-graded asphalt design
- marginal materials base with a sprayed crumb-rubber modified binder seal
- foamed bitumen stabilised base with a sprayed crumb-rubber modified binder seal.

The modelling of these pavement designs showed that greenhouse gas emissions reductions, cost savings and sustainability co-benefits can be achieved using innovative pavement solutions.

The case studies analysis demonstrated some key learnings for sustainable pavement design considerations:

- Use phase emissions contribute approximately 97% of all life cycle emissions for pavements. Minor adjustments in horizontal, vertical alignment and roughness can have significant impacts to GHG emissions.
- Over the whole of life, maintenance phase emissions (including end of life treatments) have a greater contribution of GHG emissions than construction phase.
- Generally, innovations provide win-wins for GHG emission and cost reductions.

Year One and Year Two undertook a sensitivity analysis on these pavement designs, the results of this included:

- Crumb rubber modified binder (S45R) used in spray seals can be hauled large distances (> 2,000 km) and still achieve GHG emissions reductions over the pavement life cycle.
- When analysing the impact of roughness and posted speed limit on use phase emissions the results showed that emissions increase with increasing traffic speed (in a free-flowing traffic environment) and increasing road roughness.
- Significant total life-cycle emissions savings may be realised from the use of resilient pavements due to avoided maintenance and rehabilitation required.
- Electric vehicles powered by 100 percent renewables can reduce up to 45 percent of total use phase emissions, based on an estimated 77 percent of the fleet being electric vehicles by 2060.
- GHG reductions for the use of marginal materials (i.e., local materials) are achieved by reduced haulage distances and lower GHG emissions required to produce the materials, as compared to high quality crushed and screened materials.
- When there is an increase in carbon price, there is an increase in present value, increasing the economic benefits of a more innovative and sustainable pavement design.
- When there is an increasing discount rate, there is a decrease in the present value. A low discount rate provides a more balanced weighting of future costs over the lifecycle.
- Warm-mix asphalt technologies (produced at temperatures 25 – 30 °C lower than standard hot-mix asphalts, or 75MJ/t) reduce the GHG footprint of a pavement by up to five percent (excluding the use phase).
- The use of foaming technology for warm mix asphalt provided lower emissions than methodologies including additives of Sasobit and Evotherm, when produced at the same temperature.

The project aimed to better understand the comparative sustainability performance of pavement materials. The evaluation considered innovative pavement technologies that are in current use in Queensland against comparable standard pavement designs.

The learnings and outcomes from the project will assist in communicating the economic benefits and sustainability outcomes both to the Queensland Department of Transport and Main Roads (TMR) and our industry partners on the use of innovative pavement technologies. The case studies assessed through the project, can also provide insight to the functionality and insights possible using the Sustainability Assessment Tool.

IMPLEMENTATION OF INTELLIGENT COMPACTION TECHNOLOGY IN QUEENSLAND

This project commenced in the 2018–19 financial year to facilitate the implementation of Intelligent Compaction technology in Queensland. A comprehensive literature review was undertaken during the first year to evaluate the potential benefits of IC technology to TMR.

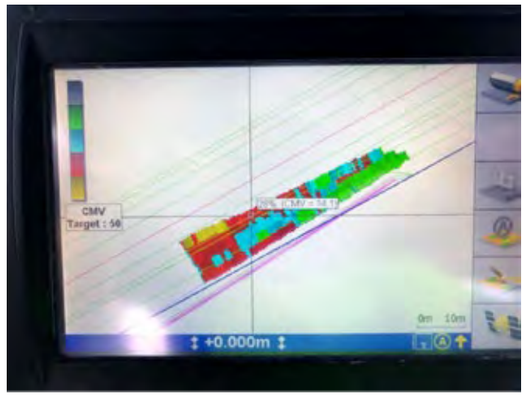
Year Two focused on the development of a pilot project-specific technical specification for use in demonstration trials. The specification was successfully trialled on the Ipswich Motorway Upgrade Stage One (Rocklea to Darra) project. The IC technology was trialled on different materials compacted as part of the project including embankment fill, subgrade, cement modified base and unbound granular base. It was found that IC technology can readily identify soft areas in a pavement or embankment and can also be used to improve the uniformity of the compacted layers.

The study showed that the Compaction Meter Value (CMV) has varying degrees of correlation against the in-situ stiffness (measured by a light weight deflectometer) and conventional density results (measured by a nuclear density gauge). It was also noted that the CMV is sensitive to in situ moisture conditions during construction. It was realised early in the project that there will be significant learning required for the industry to become familiar with IC technology and to incorporate it into construction practices.

Towards the end of this year's project (2020), we delivered an online webinar to disseminate the results from the demonstration trial. The Australian Asphalt Pavement Association (AAPA) also delivered a virtual masterclass, providing additional training on the use of the latest IC data management software, Veta 6.0. Finally, the project has funded Veta 6.0 to support the latest GDA2020 system which will soon be the main cadastral grid to be used across different jurisdictions in Australia.

To date, the project has resulted in:

- First industry workshop held in Queensland on Intelligent Compaction Data Management (ICDM) 2019, in collaboration with an expert from USA
- Project specific Technical Specification PSTS116 developed
- Utilising PSTS116 in the first major roadwork project using IC technology for compaction auditing at Ipswich Motorway Upgrade Project (March and August 2020)
- Collaboration with Logan City Council to implement IC technology on local roads
- Knowledge transfer activities (webinars).



Roller operator's view of the Trimble tablet showing a CMV map of a recent compacted area
Image Source: ARRB (2020)

Roller operator's view of the Trimble tablet showing a CMV map of a recent compacted area
Image Source: ARRB (2020)

THE USE OF RECYCLED GLASS IN PAVEMENTS

In 2018, a multi-year research project commenced aimed at increasing the use of recycled crushed glass (RCG) in pavement applications, including both unbound granular and asphalt layers.

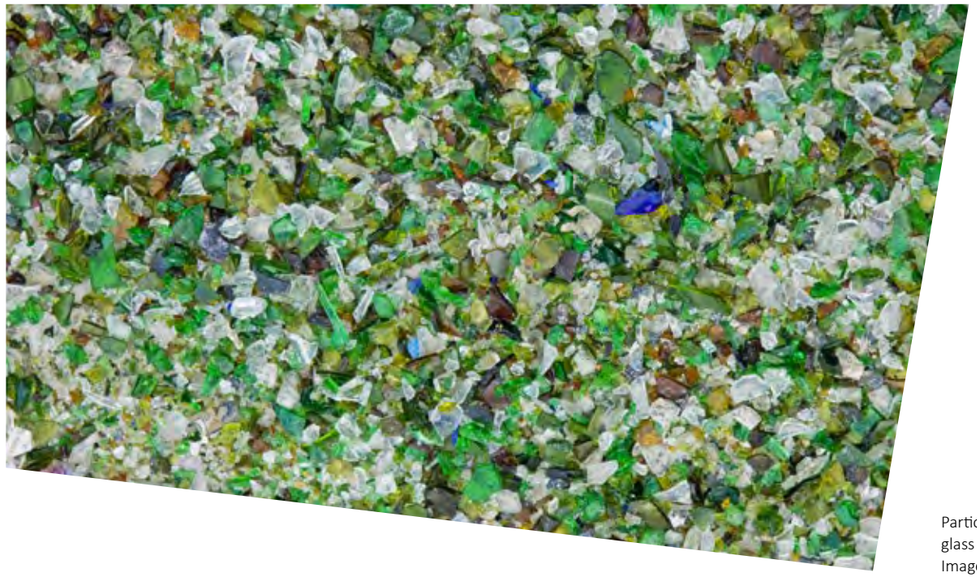
During the first year of this project a literature review was undertaken which indicated that RCG can be successfully incorporated into asphalt (within limits) without detrimentally impacting performance.

The second year of this project focused on investigating the performance of an asphalt mix containing up to ten percent RCG by mass. Additionally, an evaluation on the variability of RCG sourced from suppliers throughout Queensland was undertaken to facilitate developing new specifications for RCG and updating current specifications.

Key findings to date include:

- Asphalt layers (other than surfacing courses) may be able to contain up to ten percent RCG without detrimentally impacting performance.
- Recycled glass suppliers in Queensland can produce a consistent product appropriate for use in asphalt and unbound pavement applications.
- A new specification for RCG (MRTS36 Recycled Glass Aggregate) was developed which specifies the requirements for the use of RCG in asphalt and unbound granular applications. MRTS30 Asphalt, MRTS101 Aggregates for Asphalt and Technical Note 148 Asphalt and Micro surfacing Mix Registration were also updated to facilitate the use of RCG in TMR registered asphalt mixes.
- RCG meeting the proposed specification limits does not pose any increased risk to health and safety or the environment when used in asphalt, unbound granular pavement materials or pipe bedding materials.

Future stages of the project will include demonstration projects using RCG in asphalt and further investigating the use of higher percentages of RCG in surfacing courses.



Particles of crushed shattered glass at a recycling facility
Image Source: Shutterstock

OPTIMISING THE USE OF RECYCLED MATERIALS IN QUEENSLAND FOR UNBOUND AND STABILISED PRODUCTS

The uptake of recycled material usage in unbound granular and stabilised pavements has been relatively limited in Queensland since the 2010 publication of MRTS35 Recycled Materials in Pavements.

This has been due to various reasons, including possibly the perception that recycled materials are inferior to virgin materials and procurement barriers associated with having separate specifications for recycled and natural/quarried materials.

This project was initiated to facilitate the increased use of recycled materials in unbound pavements. The first year of the project included a literature review of existing practice in Australia focussing on the permissible uses of recycled materials in unbound pavement layers. The review found that the use of recycled materials is widely accepted in unbound and stabilised pavement materials throughout Australia. Additionally, the state road agencies outside Queensland, in NSW, SA and Victoria have combined or have closely aligned their specifications for traditional quarried materials and recycled materials, and this allows for a simplified process in specifying alternative materials in tenders and/or contracts. Based on the findings of the desktop review, recommendations were made to review current TMR specifications to facilitate the increased use of recycled materials in unbound and stabilised pavement layers.

Future project phases will assess the characteristics and performance of locally sourced recycled materials and investigate potential changes to current TMR specifications and practices.

Recycling plant in Townsville
Image Source: Queensland Department of Transport and Main Roads (TMR)

SELECTION AND USE OF UNBOUND GRANULAR PAVEMENTS WITH THIN ASPHALT SURFACING

This three-year project started in 2017 with the aim of improving the understanding and design methodology associated with unbound granular pavements with thin asphalt surfacing (TAS-UB). TAS-UB are an economical pavement type for low to moderately trafficked roads in urban environments, or in rural environments where sprayed seal surfacing does not meet the serviceability requirement.

A literature review and an investigation into the in-service performance of TAS-UB segments were carried out in year one of the project. This was followed in year two by a more detailed investigation involved test pits on selected sites of performing segments aiming at confirming the composition and quality of the unbound materials.

In the third year, a method was established to determine the maximum allowable traffic threshold for three surfacing types, namely: conventional bitumen-DGA, polymer modified binder (PMB)-DGA and stone mastic asphalt (SMA) on two basecourse types, namely unbound granular and lightly bound granular. The performance parameters used as input to the method were crack initiation and curvature from the Intelligent Pavement Assessment Vehicle (iPAVE) survey. A draft selection guide of TAS-UB was proposed and provided in Table 1.1.

BASE TYPE	Maximum allowable traffic (ESA/day at opening) for various surfacing types[1,2,3,4]		
	AC10 or AC14 with C320 bitumen	AC10 or AC14 with A15E binder	SMA
Type 2.2 or Type 3.2	10	10	10
Type 2.1 or Type 3.1	125	200	250
Type 1 (HSG)	150	250	300
Lightly bound base	250	1000 (3000)[5]	1000 (3000)[5]

1 The pavement must be designed in accordance with the TMR Pavement Design Supplement (overall pavement thickness, base thickness, layering etc.).
2 When selected in accordance with this guide, assessment of the asphalt fatigue life is not required.
3 An OG10 or OG14 surfacing, including WP-A seal, may be placed above the DGA options when required.
4 Requirements for sealing the base and bonding the asphalt to the base are not part of this guide.
5 Typically, suitable up to 1000 ESA/day at opening. May be suitable up to 3000 ESA/day following project-specific assessment

02

ASSET MANAGEMENT

ASSET MANAGEMENT

The NACOE Asset Management subprogram has been in existence since the commencement of the NACOE research program and has focused on advancing asset management knowledge and practice through improved risk assessment and evidence-based performance modelling and the underlying assumptions within these models, and the application of these as part of continuous business improvement.

In addition, the program has included research into new funding strategies that explore life cycle costing implications, particularly considering the risk of major weather events and flooding across Queensland.

The projects undertaken since the program began are listed in the table, including completion status and links to publications. Several projects produced outputs for TMR's internal use and remain unpublished.

It is expected that the program will continue to deliver benefits to the department through:

- More robust risk assessment methodologies and asset management tools and models, which will enable the department to better prioritise maintenance and rehabilitation spending, through more informed, risk-based decision making
- Whole of life cycle cost-based approach to assessing pavement impacts from heavy vehicles
- Lifecycle costing of asset management strategies, with a focus on how to improve resilience of the network to rain and flood events with a limited budget and against increasing climatic threats, and
- Assisting the department and regions with the implementation of business improvements aligned with ISO55000 and the Austroads Guide to Asset Management.
- The continuation of the program into 2020/21 includes the following approved projects:
- A cross-program infrastructure gap analysis considering network preservation, safety, connectivity, and resilience
- Roadside and road surface delineation Element Management Plan review and development
- Investigation into innovative methods to inform network management of skid resistance
- Improved basis for seal life estimates in asset management: Implementation stocktake and validation of PMB and C170 performance.

ASSET MANAGEMENT STREAM LIST OF PROJECTS UNDERTAKEN (2013 - 2019)

#	TITLE	PERIOD	PLUBLICATION STATUS / LINK
A3	Improved Network Level Asset Management Analysis Using Structural and Surface Condition Data	2013 - 14	Unpublished
A4	Accounting for Life Cycle Costing Implications and Network Performance Risks of Rain and Flood Events	2013 - 16	Published on NACOE Website
A5	Incorporating Uncertainty in PMS Modelling	2013 - 16	Published on NACOE Website
A6	Implementation of Skid Resistance Management Plan (SRMP) Including Knowledge Transfer (training)	2013 - 15	Published on NACOE Website
A8	Preliminary Evaluation of the Use of TSD Data as an Alternative to Established Deflection Methods	2014 - 16	Unpublished
A20	Improved Model to Predict the Remaining Life of Sprayed Seal Surface	2014 - 18	Published on NACOE Website
A21	Road Deterioration Model Review for Queensland	2015 - 16	Unpublished
A26	Incorporation of the Pavement Risk Score into the Pavement Condition Index	2015 - 17	Published on NACOE Website
A27	Harmonisation of Pavement Impact Assessment: Updates and Extended Marginal Cost Values	2016 - 17	Published on NACOE Website
A28	Investigate and Compare Life Cycle Cost / Benefits and Performance of Line Marking and Delineation	2016 - 18	Published on NACOE Website
A34	Customer Based Level of Service in Road Maintenance	2017 - 21	Published on NACOE Website
A35	Identification of Residual Risk for Each Element and Development of a Funding Allocation Methodology for Elements	2017 - date	Published on NACOE Website
A36	Implementation of Skid Resistance Management Plan (SRMP) and Knowledge Transfer	2018 - 19	Unpublished
A37	Effectiveness and Appropriate Application of Pavement Drains	2018 - 19	Unpublished
A41	Benchmarking Asset Management Practices and Developing Improvement Actions	2018 - date	Unpublished
A44	Synthesis and Dissemination of Best Practice, Value for Money Asset Preservation Solutions and Strategies Based on NACOE and Other National Programs	2019 - date	Published on NACOE Website
A46	Improved Models for Assessing the Level of Deferred Maintenance and Renewal	2019 - 21	Unpublished

CUSTOMER BASED LEVELS OF SERVICE IN ROAD MAINTENANCE

This project commenced in early 2018 with the aim of relating customer-based levels of service (CLoS) to the technical levels of service (TLoS) used in road maintenance by TMR.

These relationships, if soundly based, allow a customer focus to asset management demonstrating that the CLoS is being met as much as practically possible within the constraints of available budgets and asset management strategies. CLoS was categorised into five indicator categories of: safety, reliability, accessibility and rideability, with the safety elements based on the AusRAP system.

A workshop style pilot survey was conducted in 2017/18 to test the survey methodology on a limited number of participants who were selected from the Department of Transport and Main Roads (TMR) and local government road agencies in Queensland. An extended online video survey was conducted in 2019/2020, across four of the CLoS indicator categories, with members of the public.

In the continuation of the project in 2020/2021 a detailed statistical analysis will be undertake, in addition to the development of a final report covering all years of the project.

Person driving on Australian highway
Image Source: Shutterstock

SYNTHESIS AND DISSEMINATION OF BEST PRACTISE ASSET PRESERVATION SOLUTIONS AND MANAGEMENT STRATEGIES FOR SEALED ROADS

This project was undertaken to answer a need within the Queensland Department of Transport and Main Roads (TMR) to increase awareness and application of best practice technical and asset management solutions.

The project covered a review of challenges and opportunities related to increasing awareness within TMR. The information was based on visits to TMR Districts as part of the Queensland Road System Performance Plan (QRSPP) review process. This led to creating a set of customised information sessions for TMR staff, which were undertaken as webinars throughout June- September 2020 and recordings of the webinars were provided to TMR for internal distribution only.

The list of potential topics was reviewed with TMR, and the following information sessions were selected:

- Road network resilience – the effect of extreme flood events
- Asset management costs and pavement impact assessment
- Developing road user levels of service
- Construction of pavements in expansive soils
- Improved line-marking for wet areas
- Improving the pavement management system
- Skid Resistance update
- TMR advertised the webinars using the internal intranet and emails. The details for each webinar registration are shown in Table 1.1.

Webinar Name	Number of People Who Viewed the Detailed Webinar Invitation	Number of People Who Registered for the Webinar
Road Network Resilience	237	130
Asset Management Costs and Pavement Impact Assessment	198	121
Improved Line-Marking for Wet Areas	188	110
Construction of Pavement in Expansive Soils	190	112
Improving the Pavement Management System	176	111
Developing Road User Levels of Service	191	119
Skid Resistance Update	260	107

The numbers indicated the subject and content of the webinar was of interest to the TMR audience. The TMR attendees explained they would like more opportunities to follow new research using webinars in future. The presentation slides and recordings of the webinars were provided to TMR to make available through the intranet.

IMPROVED MODEL TO PREDICT THE REMAINING LIFE OF SPRAYED SEAL SURFACES

Large parts of the Queensland Department of Transport and Main Roads (TMR) road network consists of unbound granular bases with sprayed bituminous seals. Queensland has a range of climates that can vary from equatorial to desert, often with widespread flooding, so it is critical to ensure road pavements are effectively waterproofed.

The currently available sprayed seal life prediction model involves time-consuming laboratory testing which is limited to only being applicable to straight run binders, whereas a large proportion of the existing sprayed seal road network consists of modified binders. In addition, the existing field test is considered too subjective, non-repeatable and inaccurate.

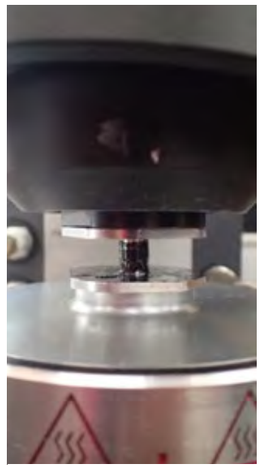
This project started in 2013, with the initial aim to reduce risks associated with early or late resealing by identifying a surface scanning device that could aid in the estimation of the remaining life of sprayed seal pavements. However, it was concluded in year two that no device could either be developed or employed for immediate use.

A revised approach was adopted in year three to assess the potential of significant surface cracking of the sprayed seal network and relate this to the characteristics of recovered binders, operating conditions, and the environment. With contribution from TMR's districts, field samples of both straight-run and modified binders were collected during years three and four of the project to represent the three different stages (fresh, mid, end) in the life of seals.

Field sampling from TMR Districts
Image Source: Queensland Department of Transport and Main Roads (TMR).

The Dynamic Shear Rheometer (DSR) was selected as a preferred testing method for both straight-run and modified binders. Several viscous flow parameters are derived from the observations made during a DSR test, including the DSR viscosity, stress at 3 strain (S3s), stress at 10 strain (S10s), and the stress ratio (Sr = S10s/S3s), which was used to explore its relationship with binder age and as a possible replacement indicator for the 'durability' parameter in the current Australian Road Research Board (ARRB) seal life model.

Testing equipment



Binder sample

DSR testing equipment
Image Source: ARRB Labs.

In year five, the DSR testing was completed for all collected samples. Testing also included the Fourier Transform Infrared (FTIR) spectroscopy analysis device to confirm whether the binder samples were a polymer modified binder (PMB) or a straight-run binder. These tests provided a clean and complete dataset as a basis for deriving the preliminary seal life models.

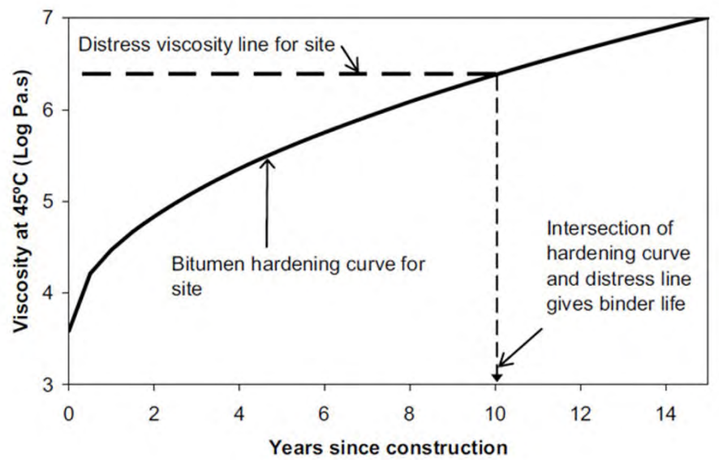
Concerns with the accuracy of the seal age of the samples were addressed by cross checking the rheological properties of the samples against the seal condition assessment results, where they were available, for comparison with TMR's inventory information.

Final Project Outcomes – Interim Seal Life Model

Year six included a review of the current ARRB seal life model, and the development of a preliminary bitumen hardening model and a preliminary distress model that were combined to derive preliminary seal life models.

An interim model to estimate seal life based on combining the straight-run bitumen and lightly modified PMB samples was produced as the outcome of this project.

Future work will include field inspections jointly undertaken by TMR and the Australian Road Research Board (ARRB) to evaluate the effectiveness of the interim model on hundreds of TMR's sprayed seal sites in Queensland.



Seal Life Model illustration

03

STRUCTURES

STRUCTURES

Significant investment has been made by the Queensland Department of Transport and Main Roads (TMR) within the NACOE Structures program in the last five years. Twenty-five projects have commenced and been delivered by the ARRB Structures team in collaboration with TMR project staff, with outcomes from completed projects implemented into TMR practice.

The NACOE Structures subprogram seeks to deliver benefits to the network in several ways through targeting research that will achieve outcomes:

- Driven cost savings in design, construction, and maintenance across the network.
- Improved bridge monitoring and heavy vehicle access using advanced systems.
- Adopting the world's best practice in asset and risk management and fit-for-purpose solutions to structural issues.
- Destructive testing and analysis of vehicle interactions on load limited and critical bridges to gain a better understanding of the capacity and performance of these structures.
- Enhanced quality of repair practice, forecasting for investment and maintenance decisions.
- Improved reporting and risk prioritisation for maintenance programming and network benchmarking.
- Introduction of advanced materials and technologies into structures across the network.
- Developed TMR Structures Repair Manual for consistent use state-wide.
- Provided an updated user manual for WhichBridge, which includes a targeted guide for how to perform common tasks within WhichBridge and WhatIf modules.
- Capture corporate knowledge on the historical changes to the WhichBridge algorithms.
- Provided recommendations for the improvement of the WhichBridge algorithms to better reflect the existing network conditions and operational needs.
- Development of a functional specification for TMR bridge risk management based on state-of-the-art risk management practice including a roadmap for trialling and implementation.
- A technical specification and works procedure were developed for the replacement of transverse stressing bars (TSB) in deck unit bridges.
- Captured the current best practice in the removal and replacement of transverse stressing bars and developed standard method statements and technical specifications for the removal of damaged transverse stressing bars on deck unit bridges.
- Provided a consistent bridge jacking methodology and process for use across TMR districts.
- Improved technical capability and knowledge of staff in the following areas:
  - The use of advanced assessment technologies and instrumentation of structures
  - Bridge risks and gaps in current bridge management practice
  - Structures asset management processes
  - How WhichBridge is used in regions and stakeholders' expectations for future improvement
  - Factors that affect risk scores and risk score anomalies
  - How to use TMR existing jacking monitoring system for bridge lifting
  - Input into TMR training and learning platform in strategic asset management to be used for a broad range of stakeholders, including non-TMR entities such as Local Government.

DISSEMINATION OF LEARNINGS TO DATE

The dissemination of learnings of the overall NACOE Structures program has been occurring through various channels including workshops, seminars, conference papers, publications on NACOE website. One journal paper and several conference papers have been produced based on the outcomes of the research program to date:

- Ngo, H, Hourigan, M, and Lake, N 2019, 'Performance Assessment of Transversely Stressed Deck Unit Bridges with Damaged Transversely Stressing Bars through Field Measurements', Proceeding of 5th Conference on Smart Monitoring, Assessment and Rehabilitation of Civil Structures, Potsdam, Germany.
- Heldt, T, Lake, N, Ngo, H, Seskis, J & Eskew, E 2019, 'Bridge Management–Using Structural Health Monitoring', 9th Australian Small Bridges Conference, 1-2 April 2019, Queensland, Australia.
- Ngo, H and Mir, F 2017, 'Destructive Load Testing of Transversely Stressed Deck Unit Bridges', Proceedings of 10th Austroads Bridge Conference, 2017, Melbourne, Australia.
- Pape T, Mir F & Rooke A 2017, 'Bridge-Vehicle Dynamic Interactions: Results from Recent Load Tests', Proceedings of 10th Austroads Bridge Conference, 2017, Melbourne, Australia.
- Ngo NS, Pape T, Kotze RP and Pritchard RW 2015, Load Testing and In-service Monitoring of Transversely Stressed Deck Unit Bridges, Special Issue: Electronic Journal of Structural Engineering, Vol. 14, Issue 1, pp 85 96.
- Pape T, Kotze R, Ngo H, Pritchard R, Roberts R & Liu T, 2014, 'Dynamic Bridge-Vehicle Interactions', 9th Austroads Bridge Conference, Sydney, New South Wales, Australia.

The following project reports have been published on the NACOE website:

- S1 Measurement of Bridge- Vehicle Interaction Under Live Load (2013/14- 2015/16)
- S2 Guidelines for Monitoring of Existing Structures
- S3 Deck Unit Bridge Deck Analysis Under Live Load 2013/14 to 2016/17 (Years 1-4)
- S3: GUN-Sandgate Road Bridge Load Testing Report (2016/17)
- S6: Review of Bridge Asset Management System- Structures Inspection Manual (2016)
- S15: Long Term Performance of FRP Replacement Components and Structures (Year 3)
- S19 Geopolymer Concrete Performance Review
- S28: Review of Performance of Concrete Pipe Culverts
- S29: AS/ISO 13822 Framing Investigation into the Assessment of Deck Unit Bridge and Transverse Stressing Bar Deficiencies (2017/18)
- S31: In-line Timber Bridge Replacement Options
- S43: Improving Structures Asset Management Capability Systems (2018/19)
- S47: Impact of Corrosion Inhibitor Admixtures on Durability of Concrete (2018/19).

INVESTIGATION OF FACTORS AFFECTING FISH PASSAGE IN CULVERTS

Currently in Queensland, waterway barrier works approvals are triggered by constructing or raising a waterway barrier, which includes new or modified culverts, causeways, some bridges, and flood ways due to the associated physical barriers to fish passage. Barriers can include increased water flow velocities, vertical drops, and increased turbulence.

Fish passage requirements for culverts where waterway barrier works are required are prescriptively defined by the Queensland Department of Agriculture and Fisheries (DAF) including a requirement for full-height rectangular baffles. Where designs do not comply with the prescriptive designs the applicant must prove that the design is suitable for fish passage, and the current body of knowledge available on what is 'suitable for fish passage' is limited.

The first year of this project conducted a review of the literature relating to fish characteristics relevant to fish passage and potential constraints to fish passage posed by culverts. Fish species found in Queensland were the primary focus but some limited review of interstate and overseas literature relating to fish passage practice was also included.

A range of factors relating to fish migration were explored, including migration patterns, seasonality, regionality and triggers for migration. The current body of knowledge on fish swimming ability was reviewed, along with specific behaviours which may contribute to passage success such as station holding. Possible constraints to fish passage posed by culverts were explored, including excessive velocities, turbulence, water depth, light contrasts, and water temperature. A review of fish passage guidelines interstate and in New Zealand has been completed with the aim of identifying best practice approaches to fish passage legislation, design, and remediation.

Knowledge gaps relating to each of the topics reviewed were presented together with recommendations for potential further work.

The O17 project will progress to a second year, with a focus on developing a prototype for an alternative baffle design from precast concrete or composite materials.

Culvert structure with DAF baffles installed on LHS
Image Source: ARRB Level 2 Inspection Program

REVIEW OF WEIGH-IN-MOTION SYSTEMS AND STRATEGIES: VIRTUAL WEIGH-IN-MOTION AND HEAVY VEHICLE TRACKING – FEASIBILITY AND VALUE

The Queensland Department of Transport and Main Roads (TMR) currently manages more than 33,000 kilometres of state-controlled roads and 3,000 bridges. A key function of TMR is to optimise heavy vehicle access to the $70 billion road network to benefit the Queensland community. This project investigated the use of Weigh-in-Motion (WiM) technology to assist TMR in extending the lives of the Operational Bridges by quantifying and managing the heavy vehicle loads accessing the bridge network. A review was undertaken on best practices in Australia and New Zealand, focusing on the application of WiM to bridge management. The review also covered an assessment of WiM systems and associated technologies and details of WiM applications in Australia and New Zealand which highlighted the need for improved decision making in relation to heavy vehicle network access and bridge management.

The aim of this project was to enhance the value of WiM, classifier and other heavy vehicle data to better inform bridge safety and decision making in relation to heavy vehicle network access and bridge management, with a focus on the largest heavy vehicles (low loaders, load platforms and mobile cranes).

Enhancing the value of the existing WiM data, classifier data and other heavy vehicle data sources is expected to result in better data informing and improving heavy vehicle access and planning decisions.

The Structures research project team were able to perform:

» An exploratory analysis of WiM and classifier data provided for the period from 1 January 2019 to 9 February 2020

» An analysis of key findings based upon parameters within the WiM and classifier datasets for the vehicles of interest

» Implement the concepts of vWiM to develop applications for the combined datasets.

The project started with cleansing, filtering, and analysing the supplied WiM and classifier datasets containing twelve months of data. Specifically, the project:

1. Reclassified vehicle configuration within the classifier data to address a significant proportion of incorrectly identified vehicles.
2. Developed filters to sort the vehicles of interest from the larger WiM and classifier datasets.
3. Benchmarked the WiM records using 123 vehicle configuration steer axle masses.
4. Developed filters based on the benchmarked WiM accuracy to isolate records deemed to represent the actual heavy vehicle traffic stream with confidence.

The processes undertaken in steps one to four listed above enable:

» increased confidence of the WiM data collected at a WiM site over a period and consequently

» increased confidence in the derived low loader and load platform datasets.

With improvements to the processing algorithms and vehicle classification rules, WiM and classifier data was available for the vehicles of interest throughout Queensland for the first time. Analyses were performed to better understand:

» load platforms throughout Queensland

» low loaders throughout Queensland

» mobile cranes at select locations

» vehicles of interest to demonstrate the capacity to better understand the traffic at a specific site.

The insights generated, together with the improved understanding of data quality, provide more research outcomes for the basis for more informed, credible decisions regarding access and asset management across the network.

Building on the success of preliminary vWiM development in this project, additional opportunities were identified to further increase the value of vWiM.

MORE FROM NACOE

Other projects funded under the NACOE Program include Network Operations, Road Safety, Sustainability and Heavy Vehicle Management.

Current departmental initiatives include:

» targeted efforts to reduce the road toll through investigating key crash types and cost-effective techniques to minimise serious and fatal injuries

» reducing waste in the infrastructure sector to drive more sustainable transport solutions and reduce greenhouse gas emissions

» supporting innovation and business growth, especially in waste management and pavement construction industries

» achieving economic sustainability goals through reduced lifecycle costs and promote circular economy practices

» assessing multi-model transportation costs, driving savings through improved network efficiency, and adopting best practice modelling

» streamlining heavy vehicle policy to remove barriers to industry while delivering the best outcomes for the network.

04

ROAD SAFETY

ROAD SAFETY

CRITICAL REVIEW OF DESIGN AND DEVELOPMENT PRACTISES THAT RELATE TO ACCESS FOR PEOPLE WITH A DISABILITY (UNIVERSAL ACCESS)

The Queensland Department of Transport and Main Roads (TMR) has committed to improving the provision of accessible transport infrastructure for all users with a significant focus being placed on access for people with disabilities. TMR has refocused its efforts by publishing the revised Disability Service Plan 2017-2020 and the Disability Action Plan 2018-2022, outlining actions to be taken to enhance accessibility.

People with disability may experience risks and difficulties that other people without disability are unaware of or do not experience. This project investigated if, and where systematic transport network access failures may be occurring for people with disability and provide recommendations to improve practices in the provision of universal access for all users, including people with disability or movement impairment, and the elderly.

This project was investigated in three parts:

» **Part One:** Review of existing policies and guidance: The aim of part one was to review the current policies, standards and guidance published by the Department of Transport and Main Roads (TMR), Austroads and Australian Standards that impact the accessibility of people with disability across the transport network. This process was able to identify access issues and recommend key areas of improvement in planning and design policies, training, and guidance with the purpose to inform and lead designers, planners, engineers, and decision-makers to provide a transport network that delivers the safest and most dignified universal access possible.

» **Part Two:** Performance-based concepts and training requirements: Updates were recommended to ensure current training courses use politically correct language, demonstrate the latest standards and guidelines, focuses on universal and dignified access, and reinforces the legal ramifications of inadequate designs. The updates recommended could potentially be applied to other training courses provided by TMR where possible.

» **Part Three:** Investigation of accessibility for people with a disability and the National Disability Insurance Scheme (NDIS) considerations: The third part of the project aimed to identify what provisions need to be put in place when topography results in undignified accessibility for people with disability and to investigate if electric assistance technology and the NDIS is changing design user capabilities.

Illustrative sample of people with disabilities
Image Source: Williams (2020)

W-BEAM GUARD RAIL UNDER-RUN: DEVELOPMENT OF TREATMENT WARRANT GUIDELINES

An effort to reduce the number and severity of crashes is an important element in the Queensland Road Safety Strategy and Action Plan. The strategy is based on a Safe System approach which acknowledges that people will make mistakes, however a mistake should not result in serious injury or loss of life. A safe and forgiving road system seeks to keep the forces due to a crash within tolerable limits.

An important contribution to reducing motorcycle trauma on Queensland roads is to reduce the severity of roadside objects. This can be achieved by removing non-motorcycle friendly objects, providing traversable roadsides, and protecting motorcyclists from objects, steep embankments, and other roadside infrastructure with Motorcycle Protection Systems (MPS).

Currently in Australia, guidelines are not available to assist in identifying when safety barriers aligned with the MPS requirements should be provided to protect motorcyclists from unforgiving roadsides. Typically, the identification of sites for MPS include consideration of Black Spots, Black Lengths, or routes with high motorcycle volumes. These approaches are not all proactive or warrant-based, which makes it difficult to identify or prioritise high risk locations. Additionally, guidance for providing suitable MPS layouts and lengths is not available.

Example of under-run barrier
Image Source: FEMA (2012)

This project has developed warrant-based guidelines that will allow for sites requiring MPS's to be identified, assigned a priority for installation, and ultimately be proactively installed. This contributes to providing safer roadsides for motorcyclists and reducing the crash severity of motorcycle run-off-road crashes. The guidelines provide the following:

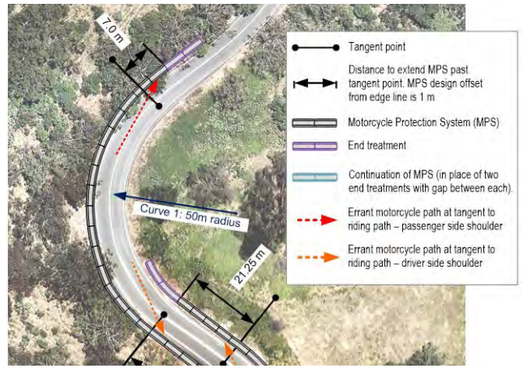
» Definition of what a Motorcycle Protection System (MPS) is.

» A decision process tree to identify where MPS should be installed which includes prioritisation for installation.

» The MPS layout and length of MPS required for a single curve or series of curves- this considers motorcycle departures from any lane when on a two-way undivided road.

The guidelines were developed from the variety of research data considered and based on the consideration of the factors contributing to a run-off-road motorcycle crash. The road attributes identified were considered for alignment with the Dutch decision tree and the Australian Road Assessment Program (AusRAP) risk factors and historical motorcycle run-off-road crash sites.

The technical guidance research findings provided by this project allows for sites to be identified and prioritised for the installation of MPS's in a proactive manner. This contributes to providing safer roadsides for motorcyclists and reducing the crash severity of motorcycle run-off-road crashes.



Example of MPS layout and MPS total length through a series of curves
Image Source: Queensland Department of Transport and Main Roads (2019)

DEVELOPMENT OF CRASH REDUCTION FACTORS

Crash reduction factors (CRFs) are an essential data component in the evaluation and prioritisation of road projects, used primarily to estimate economic savings in crashes for proposed road improvement works. It allows for various potential design options to be compared, works programs to be prioritised, and benefit-cost ratios to be estimated. The Queensland Department of Transport and Main Roads (TMR) maintains its own body of knowledge in relation to CRFs.

TMR's current database of crash reduction factors (CRF matrix) have evolved over time and as such, a review was required to ensure its continued alignment with current best practice and knowledge.

The purpose of this two-year ongoing research project is to provide a comprehensive review of the department's CRF matrix and update it with existing jurisdiction CRFs based on revision of recent research. A key objective is to improve the accuracy and scope of the CRF matrix to cover different vehicle types in different speed environments, supported by research that reflects the true safety performance of the treatment. Information was drawn from both local and international sources, including current best practices and literature, the collective knowledge of the Australian Road Research Board (ARRB) and Transport and Main Roads representatives in a series of intensive workshops.

Throughout the project, multiple gaps in knowledge were identified for specific treatments and the context in which they are applied. This made the workshops pivotal, as often the expert experience and opinion of attendees was required to arrive at a value. This reasoning and judgement should also be applied by practitioners when using CRFs so that the site-specific context of the road safety project can be properly considered. The primary output to update the TMR CRF matrix for the research case studies was achieved across multiple treatments including head-on crashes, intersection crashes, rear-end crashes, run-off road crashes, and crashes categorised under 'other'.

Crash reduction factors remain a pivotal part of the planning and prioritisation of road safety infrastructure projects and it is likely that this will continue into the foreseeable future. They are not, however, absolute, and unchangeable. The type of expert reasoning and engineering judgement applied in this research needs to also be adopted when interpreting and using the revised matrix. All road safety infrastructure projects should give consideration to be reviewed within the context in which they are proposed, and consideration given to site specific as well as wider network conditions and the effects these may have on safety performance.

AUTOMATING ROAD DATA COLLECTION FOR ROAD CONDITION MONITORING AND ROAD SAFETY IMPROVEMENT THROUGH IMAGE PATTERN RECOGNITION

For improved road safety, the Department of Transport and Main Roads (TMR) routinely undertake risk assessment of the road network for the identification and treatment of high-risk sections to manage the crash risk on the network. The risk assessment models currently used include the Australian Road Assessment Program (AusRAP), which can be quite labour intensive, expensive, and prone to many errors.

Automating the collection of road attributes from video (DVR) using advanced image analysis and deep learning, and cross-validation with other data sources such as MLS, has the potential to provide reliable, consistent, and inexpensive road condition and road safety related data sets. Research indicates that machine learning is much better at scanning video images of long stretches of roadways than human beings.

Working in collaboration with researchers from Central Queensland University (CQU), the aim of this three-year project is to develop and evaluate deep learning neural network-based methods for the automatic extraction of the road attributes required by the AusRAP risk assessment model. The ultimate deliverable of this research work is an objective, automated method, and software for identifying roadside objects and road design features for AusRAP road safety assessment.

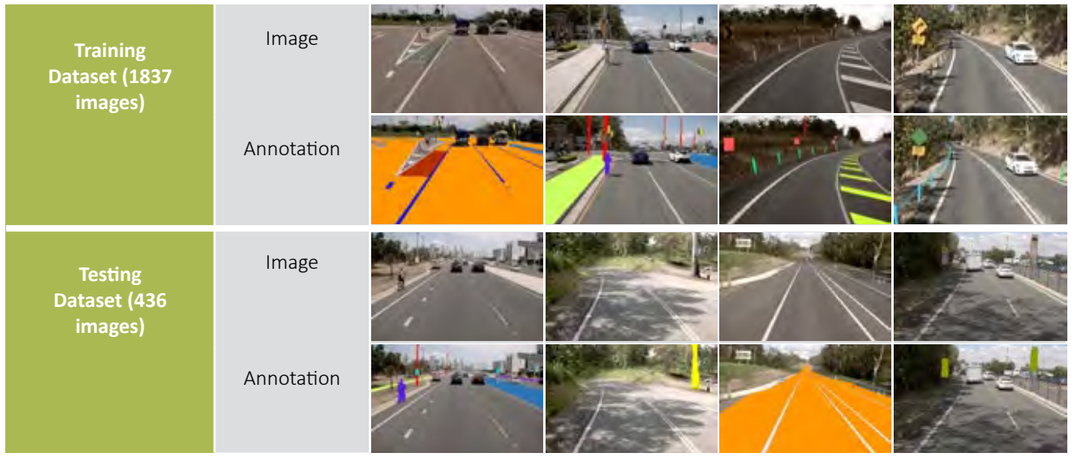
The first two years of research developed a framework and process for detecting road attributes and roadside features based on DVR video and MLS data sets. The experimental results for detecting selected road features showed promise with high precision and accuracy levels. These features include poles, trees, posted speed limit signs, line markings, paved roads, metal barriers, rumble strips, etc. A high accuracy of detection has been achieved for detecting posted speed limit signs and two most frequently occurring roadside objects, poles, and trees. Although distance calculation is more accurate on MLS data than DVR data, there were many issues with MLS data. Annotation is difficult and time consuming, the number of attributes that can be recognised is limited. Furthermore, MLS data is available for a limited number of roads.

Further development has focused on using DVR data only (due to limitations of MLS data) to:

» optimise the framework/algorithm for identifying all AusRAP attributes

» develop an automated software system for extracting AusRAP attributes.

A prototype of the software for identifying each AusRAP attribute has been completed and tested. The prototype software is based on 2273 images, manually annotated, and labelled (comprising 1837 training images and 436 testing images) from different locations with different appearances.



Some examples of the training and testing datasets
Image Source: ARRB (2020)

The finalised software has been applied to determine AusRAP attributes over a section of the Bruce Highway. Issues identified are being investigated and once complete the software will be made available to TMR for use over the state road network.

Research papers detailing the study process and findings have been presented and published in conferences and a symposium.

» Zhong M, Verma B, Affum J, Atabak S & Moir L (2018) A Convolutional Neural Network Based Deep Learning Technique for Identifying Road Attributes. International Conference on Image and Vision Computing New Zealand (IVCNZ). DOI:10.1109/IVCNZ.2018.8634743

» Zhong M, Verma B & Affum J (2019) Point Cloud Classification for Detecting Roadside Safety Attributes and Distances, 2019 IEEE Symposium Series on Computational Intelligence (SSCI) December 6-9, 2019, Xiamen, China

» Zhong M, Verma B & Affum J (2019) Deep 3D Segmentation and Classification of Point Clouds for Identifying AusRAP Attributes, International Conference on Neural Information Processing, ICONIP 2-19: Neural Information Processing, pp 95-105.

» Zhong M, Verma B & Affum J (2020) Multi-Receptive Atrous Convolutional Network for Semantic Segmentation, 2020 International Joint Conference on Neural Networks (IJCNN)DOI:10.1109/IJCNN48605.2020.9207642

» Sanjeewani P, Verma B & Affum J (2021) A Novel Evolving Classifier with a False Alarm Class for Speed Limit Sign Recognition. 2021 IEEE Congress on Evolutionary Computation (CEC) June 2021 DOI:10.1109/CEC45853.2021.9504710.

IDENTIFY COUNTER-MEASURES TO REDUCE THE LIKELIHOOD OF SAFETY INCIDENTS INVOLVING MEMBERS OF THE PUBLIC AT SHORT-TERM ROADWORK SITES (SCOPING STUDY)

Through the National Asset Centre of Excellence (NACOE) partnership, the Queensland Department of Transport and Main Roads (TMR) and the Australian Road Research Board (ARRB), seek to improve safety at short-term road works sites. Short-term road works for this project is defined as any type of road work being conducted for no longer than one shift in duration and may include short-term, low impact works.

The interaction between general traffic, road workers, plant and vehicles at any roadwork site has the potential to result in a vehicle-to-vehicle or vehicle-to-pedestrian crash, which is a significant safety risk for TMR and those involved. Traffic management practices at roadwork sites are based on the Manual of Uniform Traffic Control Devices (MUTCD) and are intended to minimise the safety risk to workers and MoP through clear and consistent traffic control methods and devices.

Despite significant improvements in guidance to design, implementation and working under a Traffic Management Plan (TMP) and Traffic Guidance Scheme (TGS), safety incidents involving members of the public continue to occur.

The purpose of this scoping study project was to identify available data sources to collect, compile, and summarise relevant data relating to short-term roadworks sites. The output of this project will assist in the work proposed for Years Two (2020/2021) and Three (2021/2022) which will involve identifying countermeasures to safety issues, conducting field trials to evaluate the effectiveness of the new countermeasures, and provide recommendations for best practises. It is expected that some learnings may be transferable to the operation of long-term road work sites.

Roadworks Ahead sign on side of the road
Image Source: Queensland Department of Transport and Main Roads (TMR).

IDENTIFY COUNTER-MEASURES TO REDUCE THE LIKELIHOOD OF INCIDENTS INVOLVING MEMBERS OF THE PUBLIC AT MOBILE LINE-MARKING OPERATIONS ON TWO-LANE UNDIVIDED ROADS (SCOPING STUDY)

Through the National Asset Centre of Excellence (NACOE) partnership, the Queensland Department of Transport and Main Roads (TMR) and the Australian Road Research Board (ARRB), seek to reduce the road toll through investigating key crash types and cost-effective techniques to minimise serious and fatal injuries.

This scoping study was conducted as part of a road safety project to improve safety for workers and drivers at mobile line marking convoy operations.

Mobile line marking convoy operations for this project are defined as operations occurring on two-lane, two-way undivided roads. Line marking can include edge line, centreline, and spot spraying so long as it is done using a moving line marking machine in a convoy.
Conducting mobile line marking convoy operations (and other slow-moving convoy operations) on high-speed carriageways present significant safety risks to field staff and members of public (MoP).

The RoadTek Operational Leadership Team (ROLT) recognises the seriousness of this issue and the implications for all RoadTek operations. A previous project undertaken through the Transport Academic Partnership (TAP) by Centre for Accident Research and Road Safety – Queensland (CARRS-Q) identified that there is little research to date specifically examining safety risk around mobile line marking operations on two-way, two-lane undivided roadways. However, the research did identify that whilst a large majority of drivers understood the varied instructions similarly, some confusion remained around messaging and guidance. Despite significant improvements in guidance to design, implementation and working under a Traffic Management Plan (TMP) and Traffic Guidance Scheme (TGS), safety incidents involving members of the public continue to occur.

The objective of this scoping study project was to identify available data sources, and collect, compile, and summarise the relevant data relating to mobile line marking convoy operations. The output of this project will assist in the work proposed for Years Two (2020/2021) and Three (2021/2022) which will involve identifying countermeasures to safety issues, conducting field trials to evaluate the effectiveness of the new countermeasures, and provide recommendations for best practises.

Road Tek Line-marking machine
Image Source: Queensland Department of Transport and Main Roads (TMR).

Road Tek Line-marking machine convoy
Image Source: Queensland Department of Transport and Main Roads (TMR).

05

NETWORK OPERATIONS

NETWORK OPERATIONS

REAL-TIME DETERMINATION OF SPARE CAPACITY OF ROUTES FOR ENHANCED MANAGEMENT OF CONGESTED ROAD NETWORKS

A system that can determine real-time roadway spare capacity has been considered an important ingredient to advance traffic management strategies but has been constrained by the geographical coverage of traffic data. Knowledge of spare capacity in real-time would lead to enhanced traffic management strategies and techniques, such as providing more accurate traveller information, gating and managing or optimising traffic signal control strategies. Such a system may now be possible with the rapid transaction of loop detector, probe, and Bluetooth data.

This project is a multi-year project that aims to develop a system for determination of real-time spare capacity in four stages as follows:

» Stage One: Industry Review and Design Capacity (Year One)

» Stage Two: Stakeholder Consultation, Prototype Development and Case Study (Year Two and Three)

» Stage Three: System Review (Year Four)

» Stage Four: System Development (Year Four and Five).

Stage Two (Year Two) undertook a process to develop the prototype program which can determine spare capacity using historical data. Consultation with the stakeholders, and in the analysis, indicated that determining spare capacity was a challenging task. As it was identified that site-specific calibration will be required during the case study which will be achieved in Year Three. As part of the calibration process, variations in traffic conditions shall be reviewed, taking into consideration high pedestrian activity, lane drops, side street movements and when signal plan changes occur. Year Three will achieve the following:

» Case study using the prototype algorithm to assess case study corridor, which will be Smith Street Motorway and North Street in both directions. The prototype will input traffic data from the case study corridor and apply the methodology developed in Stage Two. The prototype will output estimates of operational capacity, which will be validated against video data captured during the same period as the input traffic data. Where needed, the algorithms within the prototype will be calibrated to improve the estimates of real-time operational capacity.

» Final Report summarising the learnings of Stage Two, identifying the tasks undertaken and providing conclusions and recommendations.

DEVELOPMENT OF HYBRID DATA MODEL PROTOTYPE FOR ENHANCED COST OF CONGESTION (COC) METHODOLOGY

The Queensland Department of Transport and Main Roads (TMR) aims to provide an automatic system to report the cost of congestion (CoC) of a network with roads from different jurisdictions (e.g., TMR and local governments). A hybrid data model, which blends in data from multiple sources (including detection loops, Bluetooth devices and probe vehicles), is considered the ultimate data source. This project was set up to develop a web-based prototype system that can test the main functions of the automatic system before the product implementation. It is also aimed to test the quality and performance of hybrid data when compared to current available individual data sources.

Year One of the three-year project (2018-19) developed a web based CoC prototype system that incorporated multiple data sources including the intelligent hybrid data model and conducted the enhanced CoC calculation and reporting at link, route, and network level.
Year Two (2019-20) further enhanced the intelligent hybrid data business rules and quality, provided more in-depth CoC comparison between multiple data sources, and further refined prototype system functionality and useability.

The prototype developed is intended as a starting point to enable TMR to apply the CoC methodology at a network level. The prototype has the flexibility and potential to serve as a standalone visualisation tool for internal CoC reporting and can also be further transitioned in a different environment (netBI or custom implementation) that automates the CoC analysis upon completion of this project.

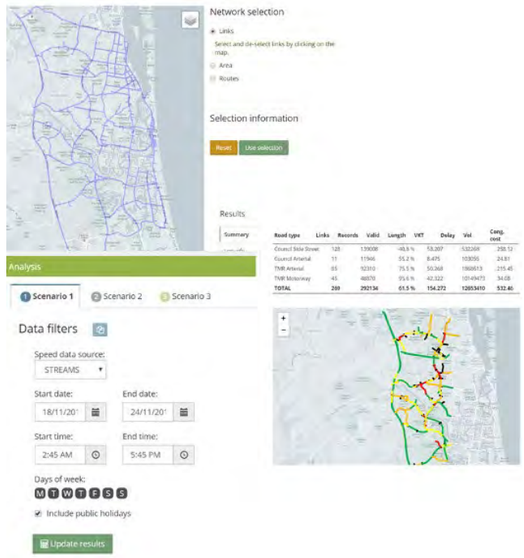
Year Two of the project has improved the quality, coverage, and confidence of accuracy of hybrid data using the prototype and analytical assessment. Some additional findings are highlighted as follows:

For both route level and link level comparison, hybrid had best coverage among all sources; the coverage of hybrid smoothed (using weighted average hybrid value of three consecutive time interval) was generally slightly higher than hybrid raw.

The map visualisation tool in the prototype provides a straightforward snapshot of the comparison between data sources.

Compared to STREAMS, hybrid data improved the data coverage from 56 percent to 83 percent (hybrid raw) or 85 percent (hybrid smoothed), significant reduced network CoC per VKT by up to 37 percent. Among all sources, HERE had the highest CoC per VKT (nine percent higher than STREAMS), and Bluetooth had the lowest CoC per VKT (44 percent lower than STREAMS).

Year Three (2020-21) will focus on further expansion of the hybrid dataset from four months to 16 months, calibration of volume data by using permanent count sites volume, further improvement in hybrid data accuracy, and finalisation of the prototype and hybrid data model enhancement.



A snapshot of the prototype visualisation tool
Image Source: ARRB

BENEFIT ACHIEVED BY MAJOR INFRASTRUCTURE PROJECT IN THE STUDY AREA OF BRUCE HIGHWAY

This project aims to better understand the change in cost of traffic congestion on the Bruce Highway, as a result of a range of smart motorway treatments and major infrastructure projects implemented in the last five years. This study informs the effectiveness of smart motorway treatments that were implemented and assesses the potential impacts of a series of major infrastructure projects on the performance of the Bruce Highway southbound (citybound) and the broader road network. The results can also assist in determining the effectiveness of past investments, inform future investments, and benchmark performance.

Four major infrastructure projects relevant to Bruce Highway or response strategies were identified for benefit evaluations as follows:

- Ramp metering, variable speed limit (VSL) and automatic queue detection and queue protection (QPQD) systems
- Boundary Road interchange
- Gateway Upgrade North (GUN)
- Redcliffe Peninsula Rail Line (RPRL).

This study covered the following two parts:

- Part One- Bruce Highway traffic performance evaluation: focus on the before-and-after comparison for Bruce Highway southbound to assess the impacts of the first three projects listed above individually.
- Part Two- Travel choice changes investigation: investigate how the infrastructure works influenced mode choice and impact on Bruce Highway and the broader road network, particularly focused on evaluation of RPRL and GUN projects.

The benefits and impact of the four major infrastructure projects are summarised as follows:

1. Ramp metering, VSL and QDQP systems
   It was observed from the data that the largest improvement occurred when all Smart Motorway treatments (ramp metering, VSL and QDQP) were activated. The before-and-after comparison (2015 versus 2017) revealed significant congestion reduction on Bruce Highway. While there was still ongoing traffic disruption from the GUN project, after-period data revealed a 21 percent reduction in normalised excessive delay cost and 23 percent reduction in both normalised reliability cost and total cost. QDQP added significant benefits to the Bruce Highway congestion reduction.

   The implementation of ramp metering, VSL and QDQP systems were also able to increase the Bruce Highway operational capacity before the flow breakdown and maintain at higher operational capacity after the flow breakdown.
2. Boundary Road interchange upgrade
   Significant reduction in motorway congestion cost was observed from a before-and-after comparison (2016 versus 2018) for the links directly impacted by the upgrade. While the average weekday peak period VKT increased by three percent, the normalised excessive delay cost, reliability cost and total cost were reduced by 55 percent, 45 percent, and 47 percent, respectively.

   However, due to over-lapping of project time frames, a portion of the reduction in congestion cost should be attributed to the benefits of ramp metering, VSL and QDQP systems.
3. **GUN**
   The completion of the GUN project led to an operational capacity improvement, attracted a large increase in demand for the Bruce Highway southbound and at the same time eased the peak period congestion significantly.

   Comparing the selected periods between 2018 and 2019, while 2019 had an increase of 12 percent in average daily peak period VKT for the links directly impacted by the GUN, the normalised excessive delay cost and total costs were reduced by 67 percent and 17 percent, respectively. However, the completion of the GUN also led to a stagnation of public transport usage in the study area despite consistent population growth.
4. **RPRL**
   Following the opening of the RPRL in October 2016, an instant shift towards a higher public transport (rail) mode share can be observed. Comparing June to August 2016 (before-period) to June to August 2017 (after-period), the mode share at SL 3 increased from 0.1 percent to 5.7 percent (plus 5.6 percent). This trend of above-average values for the RPRL also continued into 2018. The mode share shifts at the other SLs were lower (plus 1.4 percent to plus 3.9 percent), but they increased as well indicating an uptake of public transport usage. It is concluded that the above average figures for the RPRL are due to the particularly high population growth near the new RPRL (SL 3) as well as due to the availability of the new rail line with increased capacity, and truncation/ rerouting of bus services.

   As part of the project, the project team also developed a beta version Bruce Highway cost of congestion analysis Excel spreadsheet tool that enables fast processing of the before-and-after analyses. This tool can be used directly to compute the excessive delay cost, reliability cost, average volumes, average speeds, vehicle delay and other key performance indicators on a link level or route level of the Bruce Highway study route.

Study area of Bruce Highway
Image Source: STREAMS (2020), Map extracted from STREAMS Explorer.

06

HEAVY VEHICLE MANAGEMENT

HEAVY VEHICLE MANAGEMENT

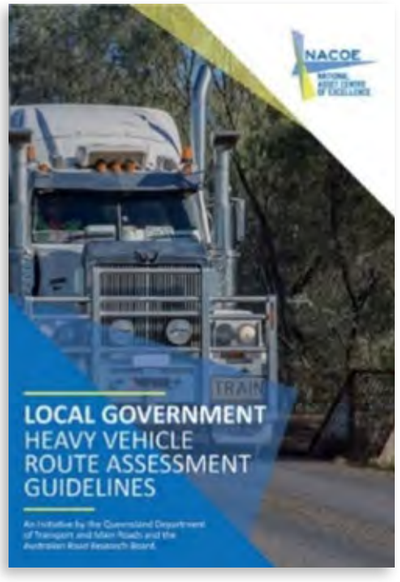
HEAVY VEHICLE ROUTE ASSESSMENT GUIDE AND ONLINE TRAINING

In 2020, a project was undertaken through the NACOE Program to improve the safety and efficiency of freight transport on Local Government (LG) roads in Queensland. The project was initially instigated by the Local Government Association of Queensland (LGAQ) and were developed based on existing heavy vehicle route assessment criteria and road engineering practice from each relevant engineering discipline. The guidelines were created to assist LG Road Managers or consultants to assess the suitability of their roads for prescriptive and Performance Based Standards (PBS) Class two heavy vehicles. The Guide is focused on assisting assessors to identify mitigation measures and adopt a risk-based approach to providing access where suitable.

The project also produced a Microsoft Excel®-based tool which included a route assessment form and a risk assessment process to further assist LG Road Managers in fast tracking assessments and navigating through the Guide.

The tool identifies which attributes on a route should be assessed and provides a high-level assessment of the route to determine which attributes meet the guideline and which require further investigation. If the road attributes on a route that do not align with the Guide, Road Managers can use the risk assessment guidance to evaluate if access could be provided through targeted mitigation measures or by applying operating conditions to a permit.

A five-part webinar series on the contents and how to use the Guide was provided free of charge and was also made available on the NACOE website. Since the Guides have been published on the NACOE website, there have been 179 downloads of the Guide, and 864 people have viewed the webinar series.



The Guides are available for download at nacoe.com.au
Image Source: NACOE

Webinar - NACOE Local Government Heavy Vehicle Route Assessment Guidelines	Number of Viewers
Webinar One- The Guide and Tools	261
Webinar Two- Risk Assessment and Traffic Considerations	183
Webinar Three- Geometric Assessment Part 1	150
Webinar Four- Geometric Assessment Part 2	127
Webinar Five- Amenities, Structures and Pavements Assessment	143

State	Number of Local Governments
Queensland	110
South Australia	17
New South Wales	16
Western Australia	9
Victoria	7
Tasmania	2

07

SUSTAINABILITY

SUSTAINABILITY

SUSTAINABILITY ASSESSMENT TOOL (SAT)

New and emerging pavement technologies provide an opportunity to increase use of recycled or non-standard materials in road construction and maintenance.

Through the NACOE program, the Queensland Department of Transport and Main Roads (TMR) and the Australian Road Research Board (ARRB) have invested in research and development of innovative pavements.
In 2018/19 the 'Assessing the Potential Greenhouse Gas Emissions Reductions and Sustainability Benefits of Innovative Pavement Solutions' project found that these new pavement designs typically have a lower embodied carbon content (i.e., release less greenhouse gases over the pavement's lifecycle), compared to standard pavement designs that use virgin materials. Some new technologies also require less construction materials due to reduced layer thicknesses and lower lifecycle cost savings.

The pavement Sustainability Assessment Tool (SAT) is a two-year project that will enable TMR to lead and implement comparative assessment of project-specific pavement designs to inform decision-making around pavement design.

The tool will allow for the evaluation and comparison of the economic and environmental sustainability impacts of pavement design options. These evaluation results will help inform decisions regarding material selection, design, and long-term maintenance strategy over the pavement lifecycle.

The first year of the project delivered a model scoping exercise that involved a user-requirements review, scoping the model outputs, determining the necessary input data requirements, building relevant reference datasheets, assessing TMR's capability to produce essential customisable input data, and outlining the key model outputs. The Australian Road Research Board (ARRB) review found the proposed model scope meets several of TMR's operational and policy needs, and already has access to the essential data needed to run the proposed model.

During the delivery of the model scoping requirements phase, TMR has partnered with Main Roads Western Australia (MRWA) to deliver the next phases of the project as a joint NACOE-WARRIP project.

In 2020/21, the project will deliver a proof-of-concept Excel-based model to enable consistent and reliable lifecycle sustainability and economic assessments of innovative pavement designs, followed by several prioritised model enhancements and a user-friendly web-based tool by the end of the June 2021.

Ultimately, the goal of the implementation of the Pavement Sustainability Assessment Tool (SAT) is that it will assist with driving the adoption of innovative pavement technologies and designs that contribute to Queensland's waste reduction, landfill diversion and recycled material use targets, and delivering on its vision to become a sustainable, low-waste, circular economy.

Reclaimed asphalt pavement

Crumb rubber

Image Source: Western Australian Road Research and Innovation Program (WARRIP)

RECYCLED MATERIALS QUEENSLAND STATE OF PLAY

This project enabled a comprehensive review toward understanding of the current state of play in Queensland regarding the use of recycled materials in road infrastructure. The project evaluated the state knowledge including standards, specifications and guidelines that cover recycled materials on the Queensland Department of Transport and Main Roads (TMR) road network which included road assets. The main deliveries included an infographic fact sheet and a technical note (TN193 Use of recycled materials in road construction) for the use of different recycled materials by TMR. A briefing paper on the possible use of recycled plastics in roads and a final project summary report were also delivered.

Initially, it was proposed to be a three-year project but Year Two and Year Three (development of an audit to catalogue existing assets incorporating recycled materials) have been put on hold as other projects had a higher priority. The delivered project milestones which allowed TMR communication's team to publish a pack of documents regarding the use of recycled materials (building sustainable roads).

There was a need within the scope to review and summarise the current usage and practices of recycled materials in Queensland, specifically in terms of TMR's roads and road assets. There was also a need to initially assess the use of recycled plastics in road infrastructure, the briefing paper served as a starting point for the bigger project between NACOE and WARRIP in this topic.

This project recognised the efforts of TMR and practitioners to contribute to a circular economy and help promote Queensland to invest in more road assets incorporating recycled materials.

Waste Not Want Not Infographic
Image Source: Queensland Department of Transport and Main Roads (TMR).

GET INVOLVED

The NACOE Program runs on a rolling four-year basis, with projects generally spanning one to three years. The program heavily relies upon the input and collaboration between TMR, ARRB and industry personnel to develop ideas for projects across the four key discipline areas of pavements, asset management, structures and other (network operations, road safety and heavy vehicle management). Any suggestions for projects can be submitted through the NACOE website **nacoe.com.au** or send an email to **info@nacoe.com.au**.

FEEDBACK AND CONTACT DETAILS

The NACOE Agreement Managers can be contacted with any feedback or enquiries regarding the program or for information on specific projects.

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