NACOE

NATIONAL
ASSET CENTRE
OF EXCELLENCE

ANNUAL HIGHLIGHTS REPORT

2021 – 2022

AN INITIATIVE BY: arrb | Queensland Government

CONTENTS

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FOREWORD BY NACOE BOARD

Welcome to the 2021-2022 Annual Highlights Report for the National Asset Centre of Excellence (NACOE). It is with great pleasure that we present this report, which marks the ninth year of outstanding achievements and advancements between the Queensland Department of Transport and Main Roads (TMR) and the Australian Road Research Board (ARRB) collaborative research agreement.

The research undertaken this year has not only contributed to the implementation of best practice frameworks but has also fostered a culture of knowledge sharing and exploration of ground-breaking innovation across Queensland and beyond. It is through this collaborative approach that we have been able to leverage our collective expertise and drive transformative changes in the transport infrastructure sector.

This year's highlights underscore the significant strides made in advancing our understanding of recycled materials technologies. By focusing on sustainable infrastructure solutions, we have taken crucial steps towards a greener and more resource-efficient future. Embracing sustainability in long-term asset performance monitoring is a priority for NACOE, and we are proud of the progress made in this direction. Read about the NACOE-WARRIP Sustainability Assessment Tool's exciting evolution- from inception to an advanced web-based interface to evaluate sustainability impacts for traditional and innovative pavement materials on page 60.

Our priority to embrace modern innovative practices, materials, and technologies remains a core focus as we strive to not only bring a positive impact to the industry but also to the community around us. We believe that by continually exploring and implementing cutting-edge solutions, we can optimise efficiency and ensure the best outcomes for Queensland's transport infrastructure design, construction, operation, and management. Read more about our focus on helping industry to facilitate safer and sustainable practices in operations and enabling circular economy outcomes on page 57.

As we reflect on the achievements of the past year, we extend our gratitude to the research teams, industry partners, and stakeholders who have contributed to our success. Your dedication and passion have been the driving force behind our accomplishments. Read about our collaboration with industry to help to promote safer, more efficient and sustainable sprayed sealing practices on page 17.

The research has benefited from working with some incredible industry and delivery partners throughout the year including:

- Working with recycled materials suppliers and the Ash Development Association of Australia (ADAA) to develop and optimise recycled material blends that will establish consistent specifications and design requirements to further increase their use in road pavements. Read more about the improved pavement performance laboratory results of recycled crushed concrete and concrete washout materials on page 20.
- Collaborating with Griffith University researchers to utilise their silicon and silicon carbide micro sensor technology toward generating real-time data monitoring of slopes with significant landslide hazards. Read about the innovative development of a wireless sensor network to help predict and prevent rainfall-induced landslides on page 22.
- Consulting with both Australian Flexible Pavement Association of Australia (AfPA) and other state transport agencies to address the high priority issue of improving safety at roadworks sites. Read about the latest emerging technologies and traffic management solutions aimed at improving industry best practices on page 44.
- Undertaking joint initiatives with the Western Australian Road Research and Innovation Program (WARRIP) to develop a framework which embeds the consideration of bushfire prevention, preparedness, response and recovery into the project life cycle of transport infrastructure. Read more about the practical, and implementable, advice for road agencies when managing the potential risk to road infrastructure caused by the impacts of bushfires on page 59.

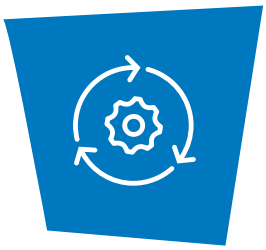
Looking ahead, we are excited to continue our pursuit of excellence and to remain at the forefront of innovation in the transport infrastructure sector. Together with our industry stakeholders and delivery partners, we will forge a path towards a safer, more efficient, and sustainable future for all Queenslanders. We hope you enjoy, and are inspired by, the highlights featured in this report.

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

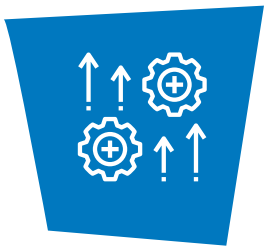
Developing the capabilities of staff and disseminating learnings to TMR regions and industry.

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 over the past eight years.

We would also like to thank and acknowledge the organisations, universities, delivery partners and industry associations who collaborated on NACOE projects. 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.

BENEFITS OF NACOE

NACOE is continuing to deliver strong economic and sustainability benefits to TMR and the broader Queensland community. The program has delivered many high value research projects since its inception. Some of the key benefits of NACOE to date include:

- progressing our investigation into Intelligent Compaction (IC) and its potential role in future road construction
- increasing the use of recycled tyres in our pavements
- delivering a pilot specification for crumb rubber modified open graded and gap graded asphalt
- reducing the thickness of heavy-duty asphalt pavements that has led to savings in construction costs, construction time and material, resulting in sustainability benefits to the community
- providing environmental benefits through improving technologies to increase use of recycled vehicle tyres in sprayed seals and asphalt
- leading the way in the technologies that enable use of higher percentages of recycled asphalt pavements
- providing research outcomes to reduce ongoing agency costs resulting in improved whole-of-life transport solutions
- informing improved asset management practices that have resulted in reduced agency and road user costs
- informing solutions for improved risk management practices for the planning, design, and maintenance of transport infrastructure
- improving our understanding of the behaviour of bridges under live traffic loading, resulting in possible cost savings due to the deferment of strengthening or replacement projects
- increasing confidence to use higher percentages of recycled materials in TMR's pavement specifications
- providing guidance toward reducing crash risks on Queensland roads.

NACOE research continued to prioritise funding to projects with clear benefits for Queensland's transport infrastructure and its management and operations.

CAPABILITY DEVELOPMENT

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

- workshops that provided enhanced understanding of the performance of Queensland's sprayed seal network
- developed technical guidance and fact sheets to assist practitioners with the application of suitable countermeasures on arrow sealed roads
- delivered several IC knowledge sharing presentations and initiatives including a road map plan for industry stakeholders to:
  - define different phases for the use IC to assist with future forecasting and ensuring the necessary equipment, software packages, trained personnel, and resources for successful on-site IC project implementation
  - demonstrate the benefits of IC technology using a benefit-cost analysis (BCA) for road authorities to consider the bigger picture and whole life cycle costs
- provided knowledge sharing of practical findings from the IC field trials including training videos for the ease of use of Veta 7.0 package for IC data display and analysis
- developed guidance and tools to support a comprehensive, risk-based framework to help assist in funding allocations of different asset elements
- developed a new Technical Note: Managing Dispersive and Slaking Soils on Infrastructure Projects
- developed a new EME2-specific design relationship capturing the unique performance benefits of EME2, which has been included in TMR's Pavement Design Supplement
- published 20 reports, presentations, and papers from 2020-21 and 2021-22, which are available on the NACOE website
- delivered four online webinars, which were published on the NACOE website.

NACOE RESEARCH PROGRAM IMPLEMENTATION

An important objective of NACOE research is to facilitate the implementation of new knowledge into practice. The outputs of the NACOE research program were implemented through:

- the development of technical notes and design guide improvements
- 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 provides synergies with the Austroads findings through NACOE ensuring that Queensland conditions and materials are fully considered. In many instances, the outputs from NACOE research have been shared with and contributed to Austroads task forces and working groups activities, which then filter through into national documents.

Research is delivered using a range of strategic research methodologies, including:

- Desktop reviews to gain an initial understanding of the research need, benefits, or application prior to progressing with a more in-depth study.
- Where relevant to providing confidence to the research outcomes, a follow-on project is often initiated that may include laboratory testing and field trials.

COLLABORATION AND DISSEMINATION OF LEARNINGS

A key strategic objective of NACOE is to facilitate ongoing development through the dissemination of learnings to industry and the regions as well as collaboration with industry, universities, and government bodies. The NACOE Board believes ongoing collaboration will allow TMR and industry to leverage off research and resources from other organisations, which in turn will deliver mutually beneficial outcomes to everyone involved.

In 2021-22, NACOE worked with multiple external organisations, including:

- The Queensland Department of Environment and Science- in research to inform development of technical guidelines and specifications for the use of recycled tyres and glass
- Local Government Association of Queensland – in research to inform to develop Local Government Heavy Vehicle Route Assessment Guidelines
- Central Queensland University – shared research to investigate an objective, automated method, and software for identifying roadside objects and road design features for road safety assessment
- The Queensland University of Technology – shared research to quantify the benefit of geosynthetics for the mechanical stabilisation of subgrade materials and develop guidelines for pavement design
- The Western Australian Road Research and Innovation Program (WARRIP) - shared research on multiple collaborative research projects
- Tyre Stewardship Australia – research to facilitate the increased use of recycled tyres in Queensland
- Logan City Council – investigating the benefits of subgrade reinforcement using geosynthetic layers and the implementation of Intelligent Compaction (IC)
- City of Gold Coast – research to implement crumb rubber modified gap graded asphalt
- Australian Flexible Pavement Association (AfPA) – research to implement IC technology into Queensland, as well as the development of a new specification for crumb rubber modified gap graded asphalt
- The Transtec Group Inc. – collaboration on the Veta 7.0 training for Intelligent Compaction Data Management (ICDM).

These collaborations are pivotal to the success of the NACOE research program and will continue in future years.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AHEAD
CHANGED
SIGNALS

01

PAVEMENTS

PAVEMENTS

The Pavements stream represents the largest proportion of the NACOE program, with a significant number of projects and approximately half the total investment. This program is focused on introducing innovation and delivering engineering best practice across several areas including but not limited to:

» asphalt

» road surfacings

» unbound granular, recycled material blends and marginal materials

» stabilised/modified pavements

» several sustainability and innovative technology projects (including alternatives to traditional pavement materials).

The findings 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 in 2021-22 included:

» informing TMR's specifications to enable reduced depth of asphalt structural layers through the adoption of Enrobé à Module Élevé (EME2) high modulus pavement

» informing TMR's design procedures to enable refinement of pavement 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)

» improving understanding 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 unavailability of conforming materials. While they offer significant savings, they can involve increased risk of poor performance, so these risks need to be understood and managed

» increasing knowledge to inform upgrading specifications, based on the review of world's best practice, and laboratory research

» streamlining use of recycled materials and recycled material blends for unbound granular pavement layers

» transferring 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.

P131 SUSTAINABLE SPRAYED SEALING PRACTICES (YEAR 1)

Sprayed seals account for approximately 90% of the Queensland state-controlled sealed road network. Given their extensive use on state-controlled roads, it becomes imperative to pursue sustainable sprayed seal practices that effectively and efficiently deliver this road surfacing method, aligning with the community's interests and supporting the Queensland Government's objectives of 'Building Queensland' and 'Supporting Jobs'.

This project focused on investigating the use of cutters in sprayed sealing activities, a long-standing practice in Australia to prevent seal failures in cooler weather and for priming prepared pavements prior to sealing. However, cutters require intensive management in construction and contribute to greenhouse gas emissions. By transitioning away from cutters, the safety and sustainability of sprayed seals can be improved. The study conducted a literature review, analysing alternative techniques such as bitumen with no cutter, bituminous emulsions, foamed bitumen, and synchronised sprayers considering their advantages and constraints.

The second part of P131 developed a draft Technical Note to guide the practice of preparing existing pavements for resealing. Good performance of a new reseal is heavily reliant on the condition of the existing road surface. Defects such as pavement failures, potholes, areas with significant shape loss and edge breaks should be repaired in a timely manner before the reseal. The project included working with TMR districts to confirm current and best practice and captured this information in a draft Technical Note. Once published, the Technical Note will help promote good practice and consistency of approach. It will also provide guidance for less experienced staff.

The project consulted with industry stakeholders to help inform best practice outcomes and also identified areas that require further investigation, evaluating industry gaps, readiness, research needs, and barriers. Overall, the outcomes of this project will help promote safer, more efficient and environmentally friendly sprayed seal practices for Queensland's roads.

Sprayed seal application to repair cracking on roads
Source: NACOE (2021)

P132 QUEENSLAND'S FOAMED BITUMEN MIX DESIGN AND STRUCTURAL DESIGN PROCEDURE: REVIEW AND IMPROVED METHODS (YEAR 1)

Queensland's Department of Transport and Main Roads (TMR) has been a pioneer in foamed bitumen stabilisation (FBS), rehabilitating over 600 km of pavements using this method since 1997. FBS finds application in both in-situ and ex-situ methods, utilised not only in rehabilitating existing roads but also in constructing new pavements for council roads and airports nationwide.

The project addressed that TMR adopts the asphalt fatigue equation for foamed bitumen structural design as an interim method, until a unique fatigue equation specific to foamed bitumen is developed. The recent Austroads' foamed bitumen fatigue projects utilising the Accelerated Loading Facility (ALF) and laboratory fatigue characterisation have provided an opportunity for TMR to review and potentially improve their structural design and mix testing procedures.

This project addressed enhanced mix design and thickness design procedures for foamed bitumen stabilised pavements, with initial steps to focus on a gap analysis and identification of possible improvements in both mix design and structural design for FBS pavement. Additionally, the project aims to improve the understanding of temperature effects on fatigue performance and enhance the temperature characterisation of FBS materials for structural design purposes. The ultimate goal will be to develop new guidance and update TMR specifications, with the first year focusing on the gap analysis and identifying potential improvements to the current practices. The findings will contribute to the ongoing improvement of FBS projects which reflects TMR's commitment to ongoing innovation and improvement in the road construction domain.

Image: Stabilisation practices on Queensland roads
Source: Queensland Department of Transport and Main Roads (2022)

Source: Queensland Department of Transport and Main Roads (2022)

Source: Queensland Department of Transport and Main Roads (2022)

P133 PERFORMANCE RELATIONSHIPS & SPECIFICATIONS FOR ASPHALT PAVEMENT DESIGN IN QLD (YEAR 1)

Previous NACOE projects have made significant progress in optimising the design of asphalt pavements in Queensland, including toward the introduction of EME2 asphalt and a new design procedure to facilitate the use of mix-specific asphalt fatigue relationships. The use of performance-based asphalt specifications and improved structural design relationships are recognised as important elements to further optimise the design and construction of asphalt pavements and facilitate the introduction of new and innovative technologies. NACOE project P133 is a multi-year research project that commenced in 2021-22 and is primarily aimed at characterisation of the performance of different TMR mix types and improving the link between laboratory tests and field performance.

The first year of the project investigated possible laboratory binder tests that can be used to predict the fatigue performance of asphalt mixes. Several binder tests using the Dynamic Shear Rheometer (DSR) were found to be promising, including the stress ratio test, time-sweep fatigue test and the linear amplitude sweep (LAS) test. Preliminary testing of a conventional C600 bitumen found a correlation between the time-sweep binder test and the fatigue performance of a single dense graded asphalt mix at different temperatures.

The research included testing to assess the link between the time-sweep test and asphalt fatigue for different binder and mix types. The project also undertook laboratory testing to characterise the modulus and fatigue behaviour of a typical TMR heavy duty asphalt surfacing mix and to assess the effect of long-term ageing on the fatigue performance of asphalt mixes manufactured with polymer modified binders. The testing is expected to be completed in 2023-24 and the project findings will be published in future reports.

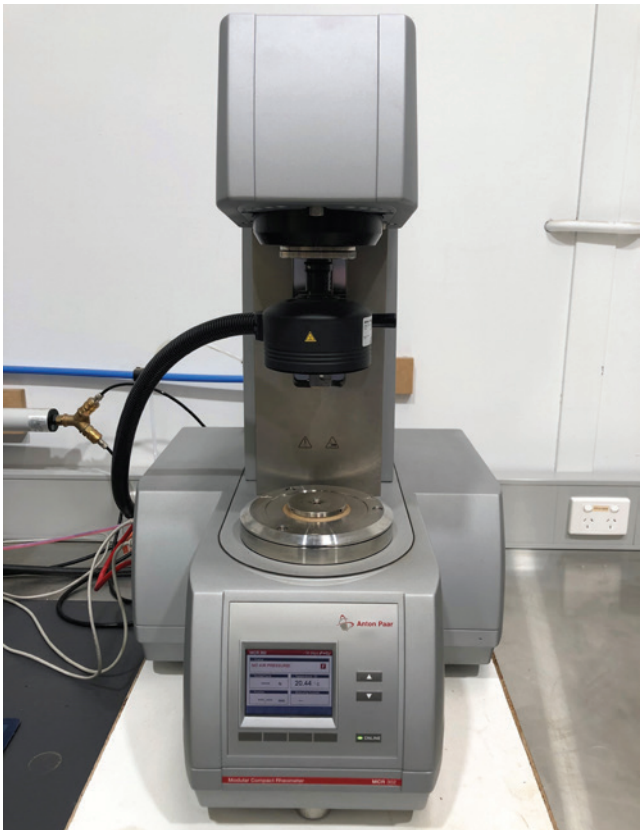

Image: Dynamic Shear Rheometer (DSR)
Source: ARRB (2022)

P135 OPTIMISATION OF QUARRIED / RECYCLED PAVEMENT MATERIAL BLENDS (YEAR 1)

As the industry moves towards a growing focus on the use and implementation of recycled materials in road construction, the Queensland Department of Transport and Main Roads (TMR) is increasingly emphasising the integration of these materials into road pavement applications, aiming to improve economic and environmental benefits and deliver sustainable road infrastructure. To facilitate this, TMR developed the MRTS35 Recycled Materials in Pavements specification to include materials from natural, quarried, and recycled sources or a combination of them; and in 2020 merged MRTS35 with MRTS05 Unbound Pavements.

This project aimed to develop and optimise recycled material blends to establish consistent specifications and design requirements that will further increase their use in road pavements.

The first year of the project focused on the laboratory performance evaluation of six recycled material blends, which included recycled crushed concrete (RCC), concrete washout (CW), and reclaimed asphalt pavement (RAP) constituents blended with crushed rock.

The project confirmed that the current test method used by MRTS05 to determine the particle size distribution was appropriate for samples incorporating RAP.

The laboratory testing highlighted that the existing MRTS05 specification pavement characterisation requirements for degradation factor and liquid limit are limited in their applicability to r assessing the recycled materials.

Based on these findings, opportunities to expand the use of recycled material blends have been identified, however, further performance-based evidence for characterisation will be the focus in the future years of the project.

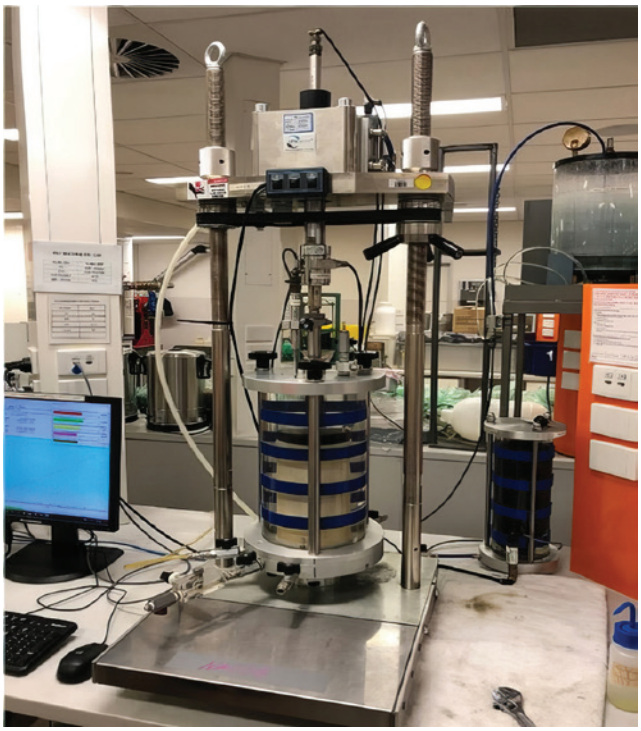

Image: TMR laboratory performance testing of recycled material blends in pavement
Source: NACOE (2022)

P139 SLOPES – DEVELOPMENT OF WIRELESS SENSOR NETWORK TO PREDICT AND PREVENT RAINFALL-INDUCED LANDSLIDES (YEAR 1)

The main objective of this project is to establish a methodology for the prediction and prevention of rainfall-induced landslides on the Queensland State-controlled road network through the development of a wireless sensor network. The project's key activities undertaken in Year One (2021-2022) included a literature review of available sensors and slope monitoring system as well as a joint site inspection conducted between representatives from Griffith University and Queensland Department of Transport and Main Roads (TMR) Geotechnical team.

To achieve the project objectives, NACOE will work closely in collaboration with Griffith University to utilise their silicon and silicon carbide micro sensor technology, which enables the mass production of highly sensitive, low-cost, and robust sensors. These non-evasive techniques and sensors will generate real-time data on soil moisture and slope movements during and after rainfall events, allowing for the identification of slopes with significant landslide hazards. Moreover, wireless sensor networks allow multiple sensors to be installed in very close proximity to each other (allowing multiple variables to be measured at essentially one point) and significantly reduce the risk of an animal, vegetation or a geological structure interfering with the network components and thus affecting the quality of the data collected.

By combining this advanced sensor technology with the latest IoT wireless communication, the project aims to create a wide-area landslide sensor network, with sensor nodes deployed along vulnerable roadside slopes. This network will act as a "nervous system" in Queensland's slope monitoring, providing real-time information and early warnings on soil conditions and potential landslides, thereby aiding authorities and drivers in traffic management and minimising life and economic losses.

Future planned work in 2022-2023 will focus on the development of sensors for soil property measurements, the creation of the wireless sensor network, and conducting laboratory and field trials. Additionally, a methodology for predicting and preventing rainfall-induced landslides will be established, and a final presentation will be made at the TMR Engineering & Technology forum and district offices.

Ultimately, the wireless sensor network developed in this project shows great potential in enhancing landslide prediction and prevention efforts, benefiting both public safety and infrastructure management in Queensland.

Image: Boar Pocket Road- 7H- Qld Monsoonal Flooding & Tropical Cyclone Olga, Neville, Ului & Paul, January|April 2010
Source: Department of Transport and Main Roads (2022)

P34 DEVELOPMENT OF PERFORMANCE BASED EVALUATION PROTOCOL FOR NON-STANDARD GRANULAR PAVEMENT MATERIALS (YEAR 3)

The majority of Queensland's state-controlled road network is composed of unbound granular pavement layers with a thin bituminous surfacing. To promote economic and environmental benefits, this project focuses on the use of locally available and/or recycled aggregates for the provision of granular pavements, especially in western regions of Queensland in arid conditions and lower traffic volume areas.

Non-standard pavement materials, also called marginal or locally sourced materials, may not adhere to standard specifications. However, when appropriately managed, they demonstrate satisfactory performance.

To optimise their suitability, this project aims to determine the best non-standard pavement materials for specific pavement applications and local roadbed conditions (fit-for-purpose). Over the years, numerous studies and reports have been conducted, documenting the sources, treatments, and performance of these materials in both regional Queensland and Australia as a whole.

In 2021-22, a significant step in the project was taken to fund and create a GIS map and database of the Department of Transport and Main Roads (TMR) technical reports that detail non-standard pavement materials used in historic projects. This GIS tool allows for the potential correlation of material types and sources with actual performance, loading, and climate events, enhancing the accessibility and utility of the existing data to inform current and future material use and research.

The ongoing effort of continually adding more non-standard pavement and materials reports to the TMR GIS database will facilitate better decision-making and research in the selection and application of locally available materials for use in granular pavements, considering economic and environmental factors.

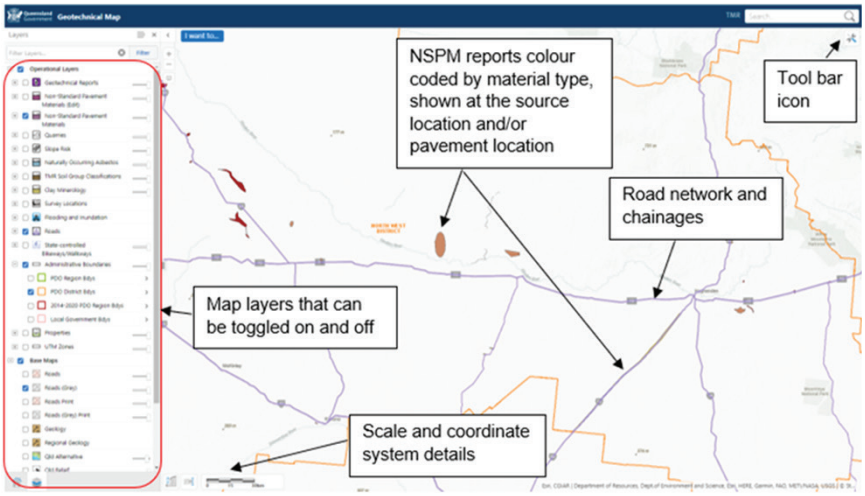

Image: iMaps features and layers
Source: Department of Transport and Main Roads (2022)

P107 INNOVATIVE METHODS OF SLAKING QUICKLIME (YEAR 2)

The use of lime as a hydraulic binder to improve a host material's properties is an established practice throughout Australia. Lime slaking is the process of adding water to quicklime (CaO) to turn it into hydrated lime. As part of the NACOE research program, ARRB and the Queensland Department of Transport and Main Roads (TMR) conducted a study to improve current best practice of slaking quicklime on the surface before stabilisation by investigating the potential for in-situ slaking of quicklime during pavement stabilisation works.

Year Two of the project focused on the initial laboratory investigation into the feasibility of slaking quicklime within the soil structure. The main objectives of the investigation were to reduce the department's dependence on hydrated lime procurement, improve construction efficiency, and enable the use of quicklime on a broader range of sites. Due to the innovative nature of this procedure, a new laboratory test method had to be developed.

Throughout the project, the test method was refined after each iteration to reduce risks and uncertainties associated with the methodology. During the development and expansion of the test method, researchers discovered additional variables related to lime product reactivity and slaking rate. The study identified a hybrid approach that combines the in-house developed calculator for determining slaking completeness based on theoretical energy releases, along with observing changes in compacted sample volume. A preliminary trial of the in-situ slaking method was conducted on a short 20m section of a temporary access road in June 2022, followed by a 200m trial to be held in June 2023. The findings indicate the possibility of slaking quicklime within a soil structure. However, further validation through a full-scale field trial would be necessary to confirm its effectiveness.

Image: Preliminary field trial segment
Source: NACOE 20m trial (2022)

P121 EVALUATION OF THE PERFORMANCE BENEFITS OF GEOSYNTHETIC REINFORCEMENT IN ASPHALT LAYERS (YEAR 2)

Asphalt pavements with geosynthetic reinforcement are widely adopted in TMR districts to prolong reflective cracking in underlying layers and improve fatigue resistance of asphalt surfacing. This delay in cracking enhances the pavement's resilience to water infiltration, leading to reduced maintenance costs and increased asset life. While products meeting minimum property parameters are available, evaluating pavement field performance that use geosynthetic products can take years. There are potential benefits to TMR projects in being able to accelerate the identification of higher performing geosynthetic products.

Year One of this project involved a comprehensive literature review on different test methods, with the decision to proceed with a wheel tracking test after discussions with internal stakeholders. Initial findings using a standard asphalt wheel tracker revealed challenges in crack propagation from the lower asphalt layer to the surfacing. Modifications were attempted to induce strain for better crack propagation, but achieving it proved difficult, and obtaining repeatable results even harder.

To expedite results, the project focused on laboratory testing of various geosynthetics in Year One. In Year Two, the project aims to address Year One's issues and perform additional testing using geosynthetic products as interlayer treatment. The development of a reflective cracking testing protocol initiated in Year One will be refined, assessing the benefits of geosynthetic reinforcement and interlayer bond strength. This research seeks to find practical solutions for more efficient and effective geosynthetic-reinforced asphalt pavements in TMR districts.

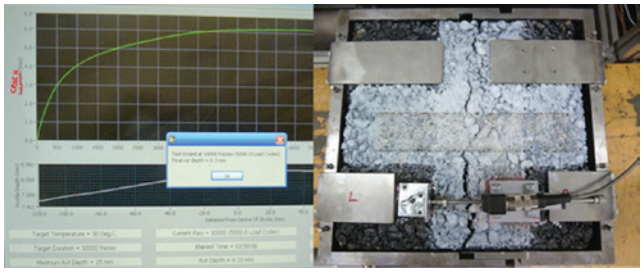

Image: AC14 without asphalt geosynthetic after 10,000 passes (5000 cycles) NACOE lab project 2021
Source: NACOE (2022)

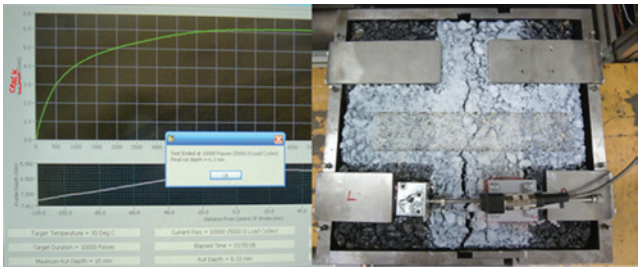

Image: AC14 with asphalt geosynthetic after 10,000 passes (5000 cycles) NACOE lab project 2021
Source: NACOE (2022)

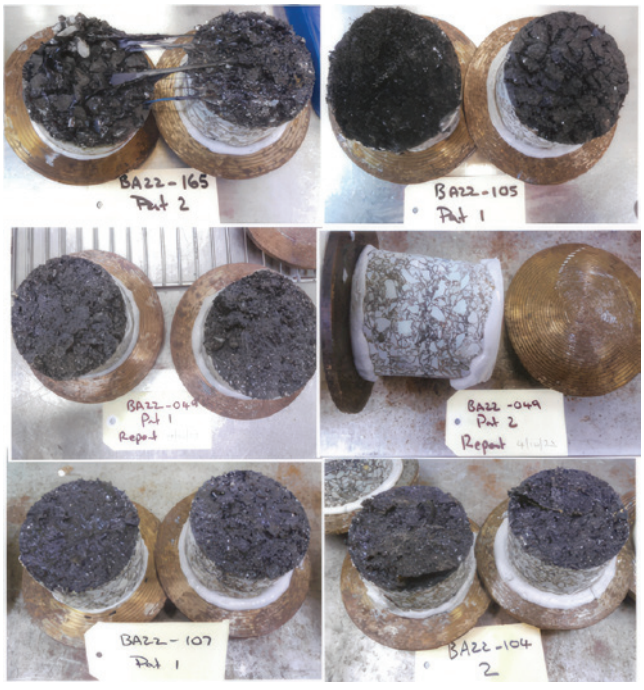

Image: Sample slab cuts for laboratory testing
Source: NACOE (2022)

02

ASSET MANAGEMENT

ASSET MANAGEMENT

The NACOE Asset Management stream has been a priority since the commencement of the NACOE research program and has focused on advancing asset management knowledge and practice. It has pursued this 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 stream 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 NACOE's inception are listed in the following table, including completion status and links to publications. Several other projects produced outputs for the sole purpose of guiding TMR and remain unpublished.

It is expected that the stream 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
- life cycle 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 2022/23 included the following 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.

LIST OF PROJECTS UNDERTAKEN UNDER ASSET MANAGEMENT STREAM (2013-22)

#	TITLE	PERIOD	PUBLICATION STATUS
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
	Implementation of Skid Resistance Management Plan (SRMP) Including Knowledge Transfer (Training)	2013 - 15	Published on NACOE Website
A6	Implementation of Skid Resistance Management Plan (SRMP) Including Knowledge Transfer (Training)	2013-15	Published on NACOE Website
	Incorporation of the Pavement Risk Score into the Pavement Condition Index	2015 - 17	Published on NACOE Website
A20	Improved Model to Predict the Remaining Life of Sprayed Seal Surface	2014-18	Published on NACOE Website
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	2017-2021	Published on NACOE Website
A44	Synthesis and Dissemination of Best Practice, Value for Money Asset Preservation Solutions and Strategies Based on NACOE and Other National Programs	2019-Ongoing	Published on NACOE Website

A27 HARMONISATION OF PAVEMENT IMPACT ASSESSMENT: UPDATED AND EXTENDED MARGINAL COST VALUES (YEAR 1)

The objective of the project was to update road wear cost estimates for sealed roads, following a similar approach used in the 2017 Marginal Cost Analysis by incorporating additional Traffic Speed Deflectometer (TSD) data and model refinements from recent studies by ARRB / TMR.

The project aimed to reanalyses the Freight and Axle Mass Limits Investigation Tool (FAMLIT) models using the most up-to-date Traffic Speed Deflectometer (TSD) data, road condition data, and unit rates but employing an alternative Pavement Management System (PMS) tool that adheres to the FAMLIT methodology to calculate long-term road wear costs effectively. An upper limit for applying marginal cost data to account for the increased pavement loading resulting from development-generated traffic was also tested. The deterioration models were further refined to align with recent studies conducted under Austroads / NACOE, testing improved methods for handling seasonal moisture adjustments, non-structural profile correction treatments, etc.

The first phase of the sealed network analysis focused on verifying the ability of alternative pavement life cycle costing demonstration tool (PLCCDTDT) to develop comparable marginal cost rates as the previously used FAMLIT. Corrections were made to the FAMLIT 2016 tool to improve accuracy, and a comparison was conducted between FAMLIT 2016 and the improved FAMLIT 2021. The PLCCDTDT was further evaluated, and results showed it provided identical outcomes to the improved FAMLIT. Hence, the PLCCDTDT was deemed suitable for future use due to its comprehensive relationships, including cracking initiation and progression, consistent with TMR practices.

PLCCDT was then used to determine marginal cost for increased loading up to 800% using linear equations, but curvilinear trends were observed in some segments, with a flattening trend for very high loadings. Based on the evaluation and comparisons conducted, the outcome of the project involved the utilization of the updated (PLCCDTDT) for the complete analysis of the sealed road network. A marginal cost dashboard has been developed for the full sealed road network of TMR through analysis/ estimation assigning representative segments where data was not available.

The adoption of the updated PLCCDTDT enhances the reliability and precision of road wear cost assessments, contributing to improved decision-making and planning for maintenance and infrastructure development on the sealed road network.

Image: ARRB TSD data collection vehicle
Source: ARRB (2021)

A43 VALUE FOR MONEY ASSET MANAGEMENT MAINTENANCE AND REHABILITATION DESIGN GUIDELINES (YEAR 1)

This project focused on achieving the best value from pavement rehabilitation (Element 18) by aligning with pavement rehabilitation design guidelines and criteria. The distinction between preservation treatments (Element 17 preventative maintenance) and rehabilitation is becoming less clear, with examples of innovative treatments that reprofile the pavement surface prior to resurfacing. Heavy patching may also be applied to localised areas before resurfacing.

The "Notional Structural Life (NSL)" concept offers a traffic-weighted measure of the structural adequacy of flexible pavements, indicating when a structural treatment is needed. Combining NSL with other measures of functional condition, such as roughness and rutting, helps identify sections needing rehabilitation or significant structural treatments. A study exploring alternative measures, like maximum deflection classified by traffic loading, is underway and will inform network modelling aspects of the project.

Project A46 highlighted the benefits of adopting these strategies, and potentially making significant savings by redefining the basis for the determination of the level of deferred maintenance and renewal costs. However, to fully realise these savings, project design would alignment between maintenance prioritisation and the asset planners' network view is required. High repair costs might also make intermediate treatments more economically viable in specific cases.

To address these needs, the project aims to:

- Conduct a stocktake of practice at an asset maintenance level and through to major projects
- Develop improved guidance and case studies to bridge the gap between surfacing design and full pavement rehabilitation
- Utilise asset management data, including Traffic Speed Deflectometer (TSD) surveys, surface distress, and profile data, to assess structural condition, treatment demand, and identify suitable treatments.

The project's key objectives are to confirm the practicality and benefits of intermediate treatments in pavement preservation, leading to cost savings, and to develop more cost-effective treatments with consistent application in district and network planning. The outcomes of this project aim to optimise the value and effectiveness of pavement rehabilitation for road agencies while considering cost-saving measures and improved design strategies for maintenance and renewal treatments.

A44 SYNTHESIS AND DISSEMINATION OF BEST PRACTICE, VALUE FOR MONEY ASSET PRESERVATION SOLUTIONS AND MANAGEMENT STRATEGIES FOR SEALED ROADS (YEAR 2)

Year two of this project aimed to continue to disseminate information throughout TMR and to industry through industry focused webinars, newsletters and articles, and transferring supporting technical data and materials to aid implementation of the outcomes of research projects.

This project was developed as in the 2018-2019 Program, NACOE A41: Benchmarking Asset Management Practices and Developing Improvement Actions was undertaken and identified a need to increase the awareness and application of the best practice technical and assessment solutions identified throughout the NACOE program, at a district level. This project sought to address the improve dissemination of learnings and support the introduction of the findings of the NACOE program into TMR practice. The focus was sealed roads, and associated assets such as drainage, and drew on the outcomes of assets, pavements and surfacing research programs. This is because the outputs of each are relevant to asset management, with a focus on minimising whole of life cycle costs to the Department, the community and industry through fit-for-purpose solutions. The program was well received and acknowledged as beneficial both by the districts and at a central level.

This stage of the project focused on the dissemination of additional technical information from:

» NACOE A34: Customer-based Levels of Service in Road Maintenance

» NACOE A35: Identification of Residual Risk for each Element and Development of a Funding Allocation Methodology of Elements.

For NACOE A34, the technical dissemination was focused on the development of an excel-based workflow, which provided a data assessment and correlation tool for understanding the linkages between Technical-based Levels of Service and Customer-based Levels of Service. This included the equations which had been developed through an online-based video survey of customer opinions of five categories of Levels of Service.

For NACOE A35, the technical dissemination was focused on the development of an excel-based workflow, which provided users with instructions on how to develop and use both the Pavement Residual Risk Model (PRRM), and the Structures Residual Risk Model (SRRM). This included a description of each of the risk indicators, data sources, risk dimensions and weights for each indicator and risk dimension. In addition, the technical dissemination for NACOE A35 included a webinar which provided an overview of the project, and a description of the development of the PRRM and SRRM.

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03

STRUCTURES

STRUCTURES

Significant investment has been made in the NACOE Structures stream in the last six years. Twenty-seven projects have been delivered and several outcomes from completed projects implemented into TMR practice.

The NACOE Structures stream delivers benefits to the transport infrastructure network in several ways with the following project target outcomes to date:

- Cost savings in design, construction, and maintenance across the network
- Improved bridge monitoring and heavy vehicle access using advanced systems
- Incorporating best practice in managing structures
- 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 statewide
- 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
- Suggest improvements for the improvement of the WhichBridge algorithms to better reflect the existing network conditions and operational needs
- Development of a functional specification for 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
- Best practice review of the removal and replacement of transverse stressing bars and development a standard method statement and technical specifications for the removal of damaged transverse stressing bars on deck unit bridges
- Developed a bridge jacking methodology and process
- Knowledge sharing 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 by TMR users, 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 stream has been occurring through various channels including workshops, seminars, conference papers, and publications on NACOE website. One journal paper and several conference papers have been produced based on the outcomes of the research program to date, including:

- Johannessen D, Heldt T, Lake N, Ngo H, Frew J 2021, 'Long-term Monitoring of a Progressively Deteriorating Bridge to Support Safe Operation', Conference Paper: IABSE Congress, January 2021, Christchurch, New Zealand.
- 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 and 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 and 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 and Liu T, 2014, 'Dynamic Bridge-Vehicle Interactions', 9th Austroads Bridge Conference, Sydney, New South Wales, Australia.

The following project reports have been published on NACOE websites:

- S1 Measurement of Bridge- Vehicle Interaction Under Live Load (2013/14- 2015/16)
- S2 Guidelines for Monitoring of Existing Structures (2015)
- S3 Deck Unit Bridge Deck Analysis Under Live Load Years 1-4 (2013/14 to 2016/17)
- 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 (2017/18)
- S19: Geopolymer Concrete Performance Review (2016)
- S26: Virtual WiM – Enriching WiM and Enhancing Decisions (2018–21)
- S28: Review of Performance of Concrete Pipe Culverts (2017/18)
- 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 (2017/18)
- S43: Improving Structures Asset Management Capability Systems (2018/19)
- S47: Impact of Corrosion Inhibitor Admixtures on Durability of Concrete (2018/19)
- S26: Virtual WiM – Enriching WiM and Enhancing Decisions (2018–21)
- S51: Suitability of the Use of Recycled Aggregate in Concrete Year 2 (2020/2021)
- S61: Optimisation of Accelerated Curing Processes for PSC and the Associated Material Performance Issues (2021-22)
- S62: Management of Structures with Concrete Halving Joint – Scale Model Testing Year 1 (2021–22).

S61 OPTIMISATION OF ACCELERATED CURING PROCESSES FOR PRESTRESSED PRECAST CONCRETE AND THE ASSOCIATED MATERIAL PERFORMANCE ISSUES

The project aimed to improve the accelerated curing processes for precast prestressed and reinforced concrete components. Notable advances in concrete technology have occurred, but the traditional curing methods have remained largely unchanged. With larger concrete elements being cured, it is crucial to find a balance between sustainability, structural performance, concrete durability, and production efficiency.

The project investigated the long-term performance of accelerated-cured concrete components used in bridges.

The project conducted a comprehensive literature review of current TMR accelerated curing practices and compared them to other state road agencies' methods. It also examined existing research on the impacts of accelerated curing on concrete performance. The study also reviewed previous TMR laboratory testing work from scoping studies.

The projects included laboratory testing where concrete cylinder specimens were cast, cured, and tested under six different curing regimes, including three accelerated methods, a dry/no curing regime, and a standard 7-day moist curing regime. The samples were tested in accordance with TMR Technical Specification MRTS70 Concrete, Nov 2018. The outcomes of testing for different accelerated curing time-temperature regimes indicated that the TMR requirement of 420 °C.h and minimum temperature of 50 °C for accelerated curing could be slightly varied in conjunction with minimum strength requirements without compromising equivalent strength and durability outcomes. The need for early strength to achieve daily production cycles, especially for prestressed concrete components, remained the primary factor determining accelerated curing regimes.

Some industry practices using concrete with higher strength grades (higher cementitious content) than specified in structural and durability designs to achieve early strength targets appeared to offset any strength and durability reductions resulting from accelerated curing regimes compared to typical 7-day moist curing. This observation was supported by findings from pre-S61 scoping studies and other literature, where high strength concretes (above ~55 MPa 28-day f'c, particularly with blended cements) achieved very low ASTM C1202 chloride penetration results, indicating less sensitivity to the curing regime.

The findings suggested that reductions in strength and durability properties of concrete compared to 7-day moist curing may not be a significant concern for TMR's precast/prestressed concretes, as long as the concrete mix design is specified in accordance with MRTS70 (Nov 2018) for the relevant exposure classification. It was noted that some of the testing was based on off-form surfaces, which may perform to a lower standard with respect to durability compared to formed surfaces.

The project report detailed the research findings and indicated the potential to include relevant findings from the experimental work in a future accelerated curing specification. Further areas of research were identified to investigate accelerated curing and concrete durability relevant to this project's outcomes.

S62 MANAGEMENT OF STRUCTURES WITH CONCRETE HALVING JOINT - SCALE MODEL TESTING PROJECT

The aim of this project is to understand the behaviour and capacity of the bridges with concrete halving joints. Halving joints (HJ) are no longer allowed in new TMR bridge design, but legacy structures are likely to remain for many years, so their behaviour and issues need to be comprehensively understood.

A bridge with halving joints consists of suspended spans with dapped ends supported on the nibs of abutments or adjacent cantilevered girders. The physical configuration of the joint introduces a sudden change in geometry, resulting in significant variation in the stiffness and strength within the joint section. Reduced cross-section stiffness and strength combined with complex localised bending and shear makes HJ vulnerable to failure, often exacerbated by other factors. Reinforced and post tensioned, suspended spans and T-Roff girders are of particular interest to TMR.

Year one of this project undertook a review of international research and best practice in the management of concrete halving joint bridges. The investigation found that significant research has been undertaken from the early 1960s regarding the performance and capacity of halving joints, with notable failures that have occurred and driven research and investment into investigation and assessment.

The UK standard CS 466: Risk management and structural assessment of concrete half-joint deck structures appears to represent a best practice management approach, indicating TMR is aligned with other jurisdictions in adopting the CS 466 methodology.

The project report detailed the relevant findings and identified gaps including the effects of post-tensioning, development length (particularly prestressed strand), fatigue, and corrosion issues affecting the HJ behaviour and capacity. Future investigation with the finite element model developed and experimental tests may further inform this.

Figure 6.6: Vertical reinforcing strain as a fraction of the yield strain

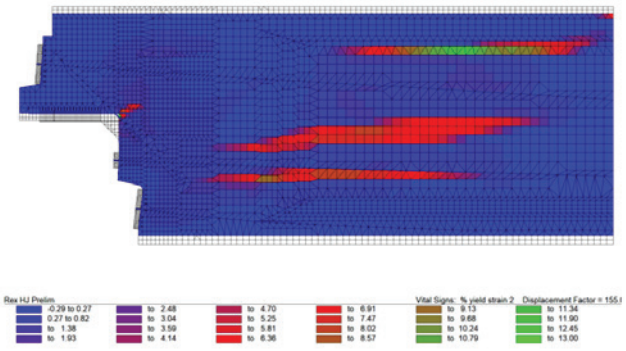

Figure 6.7: Concrete crushing index

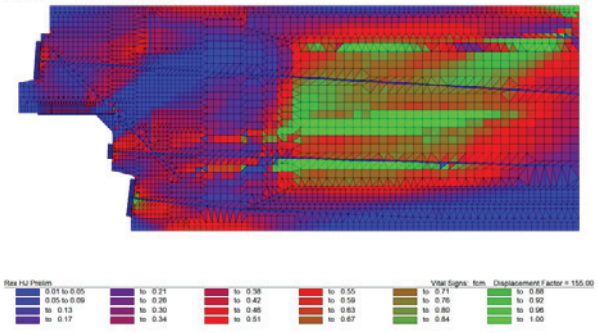

Image: Results of VecTor2 software tool used for investigating the behaviour of girder halving joints up to failure
Source: NACOE S62: Management of Structures with Concrete Halving Joint – Scale Model Testing Report (2022).

MORE FROM NACOE

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

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

R121 EVALUATION OF TRAFFIC CONTROL MEASURES AND TECHNOLOGIES AT ROADWORK SITES

The NACOE collaborative research seeks to improve safety at roadworks sites.

Hazards from live traffic at roadworks sites have been identified as a high priority issue to be addressed based on considerations of high-risk and high-impact incidents experienced across the industry. The R121 project aimed to work with industry stakeholders to evaluate a proposed set of emerging technologies and traffic management solutions to determine their effectiveness in various road and traffic environments. The project outcomes are expected to benefit through getting new knowledge into practice sooner and improving industry best practices.

A selection of two traffic control measures were trialled in the first year of the project. The technologies trialled were flashing beacons and speed radar signs using a Variable Message Sign (VMS).

The key evaluation objectives for the selected traffic control measures' trials were primarily to measure the effectiveness in reducing travel speeds at roadworks sites and improving the speed compliance of motorists at traffic roadworks sites.

- Development of a research method (in consultation with AfPA and TMR)
- Planned trial to set up, monitor, and collect data relevant to the traffic control measures
- Confirmed KPIs to measure the change in road safety performance
- Physical testing undertaken on site
- A statistical analysis of the data
- Compilation of a technical report.

Year Two of this project will conduct a second set of trials of other selected traffic control devices, comparing and analysing them with the selection made in the first year. A final project report will be produced to present the key findings.

Image: Traffic control device- Flashing beacon
Source: Canva (2022)

Image: Speed radar device at project trial site
Source: NACOE (2022)

R122 VIDEO ANALYTICS: A POST-TREATMENT STUDY OF THE INTERSECTION OF GOLD COAST HIGHWAY AND HOPE ISLAND ROAD

The use of software development incorporating machine learning, neural networks, and artificial intelligence has been growing, with multiple vendors offering video analytics as a proactive tool in road safety analysis. In a previous successful trial project on video analytics for road safety from 2018 to 2020 through the Transport Academic Partnership (TAP) program, the Queensland Department of Transport and Main Roads (TMR) was keen to further explore how these tools can be incorporated into future road safety practices for improved safety outcomes. In line with this goal, TMR was eager to establish a robust governance framework that would ensure the responsible use of video analytics.

The objectives of this project were to identify and scope video-based conflict analysis toward compiling a specification for use when procuring to undertake the estimation of crash risk via trajectory analysis.

The project approach included four stages:

- Stage One involved two parts. Stage 1A engaged and evaluated vendors who provide video analytics services in a road safety context and selected six shortlisted vendors. Stage 1B comprised of shortlisting four selected vendors to proceed with evaluating the sample 48 hours of video data provided by TMR.
- Stage Two evaluated and compared the results between the four vendors' analyses of the sample video imagery.
- Stage Three developed a specification framework for commissioning video analytics work by TMR.
- Stage Four covered further research to consider other possible data/analytics sources such as LiDAR, probe speed data and connected vehicle data to evaluate road safety aspects.

Four selected vendor outputs were evaluated based on performance in analysing the provided 48 hours of video data. Various obstacles and differences in units and graph types among the outputs complicated the comparison process, indicating that the various technologies were not advanced enough at this stage to progress to subsequent work packages and would require further investigation.

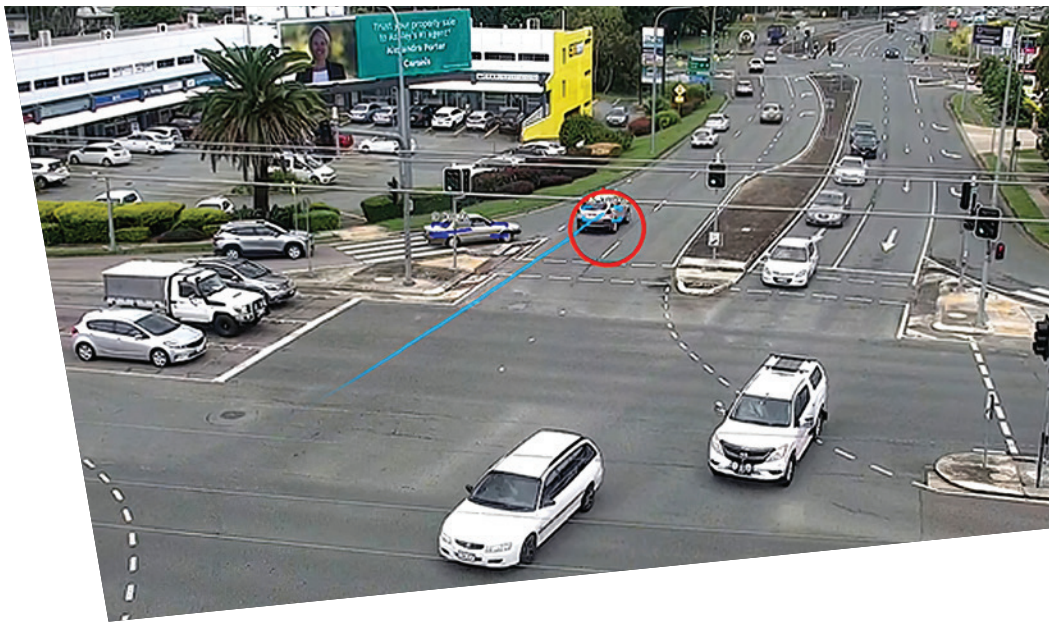

Image: Extract from video imagery showing how near-misses are identified
Source: NACOE R122 project report (2022)

CONTINUED

A detailed specification was not developed. Rather an advanced specification framework was compiled to ensure accuracy, quality, and compliance with TMR standards for any future procurement process for this type of service.

Three additional data collection technologies were investigated:

» LiDAR technology which seems promising for near-miss applications as the point cloud is believed to provide an accurate representation of the road environment. However, cost impacts considerations could impact selection and a trial project to assess robustness of results may be required.

» Probe speed data, which records sudden deceleration, abrupt steering and lane changes, providing insights into frequent driver behaviour patterns on the road network. The accuracy of probe data, which depends on the hardware used for collection (e.g. in-vehicle GPS or mobile phone locations) requires further investigation. Aggregating this data for review and conducting investigations into specific locations with unusual behaviour patterns, for example sudden deceleration, will help determine what the underlying causes are and distinguish between a minor incident such as a fallen object, or if it is a significant road safety concern.

» Connected vehicle data- which facilitates communication between vehicles and their surrounding infrastructure. The Ipswich Connected Vehicle Pilot was the largest Cooperative Intelligent Transport Systems (C-ITS) initiative in Australia at the time, testing connected vehicle technologies for their potential to enhance road safety. The system works by communicating safety information and warnings to drivers through audible tones or displayed images. A connected vehicle data product was reviewed- that can identify road safety issues and near-misses based on driver reactions like swerving and braking. A review of these connected vehicle dataset results found that further evaluation would be necessary to determine the causes of these driver behaviours and inform road safety improvements. These types of analytics rely on large datasets and trends, making it challenging to capture issues affecting a small number of drivers.

Continued trials would be beneficial in improving the accuracy and reliability of these technologies in the future in order to develop more detailed specifications.

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ONE
WAY

05

NETWORK OPERATIONS

NETWORK OPERATIONS

R113 ENERGY REDUCTION OPPORTUNITIES FOR ROAD OPERATIONS INFRASTRUCTURE – A CASE STUDY

In Australia, Queensland ranks as the second largest consumer of energy among states and territories, primarily due to the transport sector having the highest energy consumption during 2018-19. Given Queensland's extensive intelligent transport system (ITS) infrastructure, it becomes crucial to actively explore energy-saving options. Thus, the objective of this project was to investigate energy-saving measures for road operations infrastructure managed by TMR specifically excluding privately operated road infrastructure, such as toll roads and their tunnels.

A literature review was undertaken of potential energy saving opportunities associated with small-scale commercial solar PV systems, road lighting, busway tunnel operations, traffic signals and ITS field equipment which revealed several key findings.

- There were no new power reduction opportunities identified for ITS field equipment.
- Small-scale solar PV systems for public infrastructure were unlikely to yield positive returns on investment but could offer environmental benefits.
- Converting busway tunnel lighting from high-pressure sodium to LED lighting showed potential for improving visibility and safety.

Various strategies for tunnel lighting control were found to reduce energy consumption. Solar optical fibre-based lighting technology was promising for tunnel portal entrance areas, although high establishment costs and limited testing in Australia poses a challenge and is not a prioritised option for retrofitting traditional existing implementations. On-demand tunnel ventilation systems demonstrated significant electricity and noise reduction, but the capital cost of implementation was a consideration. Converting incandescent street lighting to LED technology remains an effective approach. Extra Low Voltage (ELV) LED based lanterns offer power reduction opportunities for traffic signals as well as other benefits such as improved safety and lower maintenance costs. Photovoltaic systems could be suitable for powering low-power ITS devices in applications whereby it is not practical nor economically viable to provide a power grid option. Further power reduction opportunities through intelligent operation for TMR's ITS equipment were minimal beyond existing current practices.

The project delivered a comprehensive case study report available on the NACOE website.

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06

HEAVY VEHICLE MANAGEMENT

HEAVY VEHICLE MANAGEMENT

R111 FUTURE DIRECTIONS WITH QUEENSLAND'S AGRICULTURAL COMMODITY SCHEMES

This Future Directions project sought to review and benchmark a range of agricultural commodity schemes as applicable to Queensland.

Since the creation of these schemes approximately 20 years ago, there have been many advancements in heavy vehicle technology. With that focus, the Future Directions Project undertook a comparative analysis of the conditions of each jurisdiction and focused upon key themes of relevant schemes. Industry and key agricultural organisations were consulted. The analysis expanded learnings and also highlighted the differences between the jurisdictional approaches, and an increased understanding of how emerging technologies may change the landscape of agricultural schemes into the future. These outcomes will go forward to informing further consultation and considerations.


ROAD
RAIN

07

SUSTAINABILITY

SUSTAINABILITY

O24 RECYCLED MATERIALS IN STABILISATION

There is an increasing focus on the use of recycled materials and reducing reliance on non-renewable resources. This project aimed to test the feasibility and optimise the use of different recycled material blends as host materials for foamed bitumen stabilisation and cement stabilisation.

The scope of this project was to evaluate the performance and mechanical properties of a range of recycled host material blends treated by stabilisation techniques through mix design evaluation with laboratory testing.

In Year One (2021-22), three recycled material blends were selected for the laboratory testing assessments. The indirect tensile modulus test was undertaken on the foamed bitumen stabilised recycled blends and the unconfined compressive strength test was carried out on cement stabilised recycled materials.

Year Two will be undertaken in 2022-23 to conduct similar testing on a further five recycled material blends from different suppliers.

Year Three of the project, to be undertaken in 2023-24, will build upon previous years of laboratory testing to conduct a field trial that will demonstrate construction and performance of stabilised recycled materials as a way to incentivise TMR districts and suppliers to use more of these materials in future TMR projects.

Image: Recycled materials tested in the lab
Source: ARRB (2022)

O26 INCORPORATING BUSHFIRE IMPACTS INTO ROAD DESIGN

There is growing uncertainty regarding climate variability and the impact this will have on the frequency and intensity of bushfire events. Currently, it is understood that not all road asset management planning, design and construction practices for infrastructure projects actively consider bushfire risk.

This project, a joint initiative undertaken by NACOE through TMR and the Western Australian Road Research and Innovation Program (WARRIP) through Main Roads WA, developed a framework which embeds the consideration of bushfire prevention, preparedness, response and recovery into the project life cycle of transport infrastructure, i.e. planning, design, construction, maintenance and operations.

This framework has been developed to provide practical and implementable advice for road agencies when managing the potential risk to road infrastructure caused by the impacts of bushfires.

This includes:

- reducing bushfire ignition in the road corridor through roadside vegetation design and maintenance
- reducing the impact from a bushfire in a road corridor by minimising the damage which could be done to infrastructure in the road corridor
- facilitating evacuation routes and protecting road users during an emergency, in collaboration with emergency services
- enabling quick recovery of road operations following a bushfire.

This fit-for-purpose framework was published in a report which is available on the NACOE website.

Image: Bushfire damage to safety infrastructure
Source: Mancini (2020)

P117 SUSTAINABILITY ASSESSMENT TOOL FOR PAVEMENT

The Sustainability Assessment Tool (SAT) is a comprehensive and flexible life cycle assessment tool designed to quantify the sustainability impacts and opportunities of new pavements and pavement rehabilitation treatments, incorporating both traditional and cutting-edge materials and technologies. The development of the SAT is a collaborative effort between WARRIP-NACOE, Main Roads Western Australia (Main Roads), and the Queensland Department of Transport and Main Roads (TMR).

This innovative tool seeks to address the limitations of existing assessment tools and significantly enhances the industry's ability to make informed decisions on material selection and design throughout the pavement lifecycle. By facilitating the adoption of pioneering pavement research and technologies as developed under the NACOE and WARRIP research agreements, the SAT is expected to be a game-changer for the industry.

The joint project aims to develop a user-friendly tool customised to a TMR's technical specifications, enabling Main Roads, TMR, their consultants, and contractors to accurately calculate lifecycle greenhouse gas emissions, other environmental indicators, and cost comparisons for various road pavement designs, including innovative solutions. Its overarching purpose is to facilitate Main Roads, TMR, and industry partners in quantifying and comparing lifecycle sustainability and economic opportunities, ensuring consistent and reliable assessments of innovative pavements.

The SAT's outcomes contribute to improved solutions when comparing sustainability opportunities, emissions reductions, energy and water use reductions, cost savings, and promoting circular economy outcomes. Additionally, it supports the growth of innovative pavement and recycling industries, including job creation, and aligns with the Infrastructure Sustainability Council (ISC) requirements for consistent and credible sustainability assessments across infrastructure projects nationwide.

The development of the SAT has progressed through a staged pathway, encompassing the following phases:

1. Foundational Tool Development: The initial groundwork for the SAT was laid during an earlier NACOE project.
2. Excel-based Proof-of-Concept Tool: In 2020-21, an Excel-based 'proof-of-concept' or minimum viable product (MVP) tool was created. It featured the fundamental functions required by Main Roads, TMR, and their stakeholders. Although not fully matured in terms of extended capability, design, and user-friendly interface, this MVP served as a crucial starting point for further advancements.
3. Enhanced Excel-based SAT: Building upon the excel tool, an enhanced version of the SAT was developed. It offered additional sustainability outputs and economic indicators, further enriching its analytical capabilities and applicability.
4. Web-Based Tool with Advanced Features: The culmination of the SAT's development journey is to develop a sophisticated web-based tool. This final iteration will boast a superior user interface, enhanced output visualisations, and incorporates essential features like user authentication and access controls. Its web-based nature will allow for broader accessibility and ease of use.

Through these progressive stages, the SAT tool's journey from its foundational version to the advanced web-based interface demonstrates a commitment to continuous improvement and providing cutting-edge solutions for informed decision-making in sustainable pavement design and construction.

Notably, the SAT will serve as a particularly valuable resource that will lead to more informed decision-making processes and the promotion of material selections that align with sustainable practices for their projects. With the SAT's implementation, industry can take a significant step forward in its commitment to environmentally conscious infrastructure development and a more sustainable future.

Image: Online user face of pavement design tab on SAT Tool (development phase)
Source: NACOE/WARRIP (2022)

GET INVOLVED

The NACOE Program runs on a rolling five-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 seven key discipline areas of pavements, asset management, structures, network operations, road safety and heavy vehicle management. Any suggestions for projects can be submitted through the NACOE website nacoe.com.au or by sending 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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