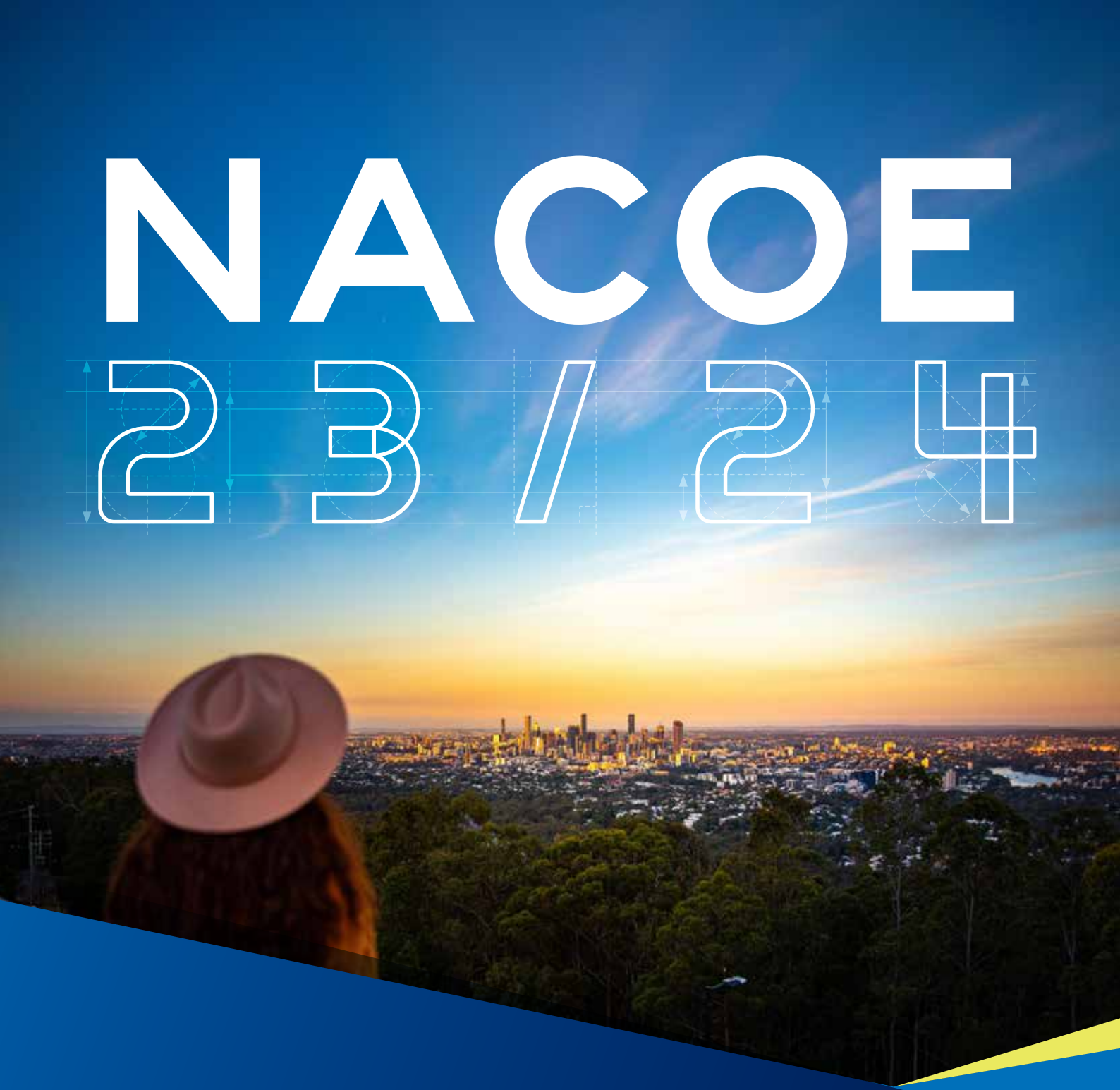
NACOE 23/24



ANNUAL HIGHLIGHTS REPORT

2023 – 2024

AN INITIATIVE BETWEEN

Queensland Government | NTRO NATIONAL TRANSPORT RESEARCH ORGANISATION

ABOUT THE PARTNERS

We want to acknowledge our partners, the Queensland Department of Transport and Main Roads (TMR) and the National Transport Research Organisation (NTRO), formerly the Australian Road Research Board (ARRB), for supporting the NACOE Program for over a decade.

Queensland Department of Transport and Main Roads (TMR): TMR moves and connects people, places, goods and services safely, efficiently and effectively across Queensland. It plans, manages and delivers Queensland's integrated transport environment for sustainable road, rail, air, and sea transport solutions. TMR's vision is to create a single integrated transport network that is accessible to everyone. The integrated transport planning approach ensures that TMR contributes to people's quality of life, Queensland's economic well-being, and a sustainable environment

National Transport Research Organisation (NTRO): NTRO (formerly ARRB) was founded in 1960 and is the source of independent expert transport knowledge, advising key decision-makers on our nation's most critical challenges. NTRO has a strong heritage of supporting and delivering high-quality applied research for Australian and New Zealand state road agency members and the community.

NTRO's vision is to help make the world's cities smarter, cleaner, greener, safer, more efficient, and more productive through intelligent transport solutions.

FOREWORD BY THE BOARD

DENNIS WALSH

Chair | Chief Engineer Engineering and Technology

Queensland Department of Transport and Main Roads

THE NATIONAL ASSET CENTRE OF EXCELLENCE (NACOE) continues to be a driving force in advancing Queensland's transport infrastructure. In the past year, our team has delivered significant outcomes that have had a positive impact on the state's road network.

A key focus for NACOE has been on sustainability and the technologies that deliver cost-effective solutions for Queensland's transport infrastructure sector. NACOE has learnt from and engaged with leaders of pavement and asset management innovations from around the world, building on new technologies and applying them to Queensland's unique requirements. Our home-grown innovation has successfully explored solutions such as the increased use of recycled materials, intelligent construction technologies, and optimised asset management practices to not only reduced environmental impact but also to avoid unnecessary costs.

In 2024, NACOE has made strides in investigating the potential of Intelligent Compaction to revolutionise road construction in Queensland. The continued implementation, testing and refinement of this technology allows for real-time monitoring and optimisation of the compaction process, leading to improved pavement quality and longevity across Queensland road network. Our commitment to safety remains unwavering. We have undertaken research to enhance safety, particularly at work sites, Queensland's expansive structures assets and on high-risk roads. By leveraging advanced technologies and data-driven insights, NACOE is working to improve our community's safety and access of Australia's transport network.

As we look ahead, NACOE will continue to prioritise innovation and collaboration. We will work closely with industry partners and academic institutions to develop solutions that address the evolving needs of the transport sector. Our goal is to position Queensland as a global leader in pavement research, sustainable solutions and efficient transport infrastructure.

The Board of NACOE extends its sincere gratitude to our dedicated staff, industry partners, and stakeholders for their invaluable contributions. Your support has been instrumental in achieving these remarkable results.

D. Walsh

DENNIS WALSH

Chair of the Board | NACOE

JASON SPROTT

Executive Director | Ports and Airports

National Transport Research Organisation - NTRO

STEPHEN MALLOWS

Deputy Chief Engineer | Engineering and Technology

Queensland Department of Transport and Main Roads

DR. RICHARD YEO

Chief Operating Officer

National Transport Research Organisation - NTRO

NACOE 2023-2024 Research Program

PAVEMENTS

P34	Development of Performance Based Evaluation Protocol for Non-Standard Granular Pavement Materials (Year Five)
P43	Long Term Pavement Performance Project (Year Ten)
P87	Incorporate Micro-Deval Testing in Material Specifications
P111	Improved Crumb Rubber Modified Binder Sprayed Sealing Practices (Year Five)
P122	Improved Characterisationof Lightly Bound Materials (Year Three)
P127	Harmonisation of Asphalt Compaction Standards (Year Four)
P131	Sustainable Practice in Sprayed Sealing Practises (Year Three)
P132	Queensland's Foamed Bitumen Mix Design and Structural Design Procedure: Review and Improved Methods(Year Three)
P133	Performance Relationships & Specifications of Asphalt Pavement Design in Qld (Year Three)
P135	Optimimisation of Quarried / Recycled Pavement Material Blends
P137	Stability of Bridge Abutments – on the Influence of Pore Pressures on Scouring of Supporting Slopes (Year Three)
P139	Slopes –Development of Wireless Sensor Network to Predict and Prevent Rainfall-Induced Landslides (Year Three)
P140	Investigate Premature Failure of Raised Reflective Pavement Markers (RRPM) and Improvement Options (Year Two)
P146	Improved Laboratory Performance Assessment of Binder in Sprayed-Seal and Asphalt (TMR DSR consistency 6% tests)
P160	Method for Determining Design Parameters of Reinforced Paved Flexible Pavement
P161	Maximising the Use of TSD Data for Pavement
P162	Accurate Binder Content Determination of Crumb Rubber Asphalt Mixes
P164	Optimised and Advanced Geotechnical Solutions (Year Two)
P165	Development of a Soft Soils and Expansive Soils Databases
P166	Synthesis and Dissemination of Research Findings and Implementation Concepts for Pavements and Sustainability
P168	Improved Resilience of Unbound Granular Pavements
P179	Intelligent Construction Technology for Better Roads in Qld
P180	T2GO Skid Resistance (Year Two)
P181	PhD Project-Industry Research Training Group (IRTG) QUT 2 PhD Projects (Year One)
P182	Alternative Laboratory Compaction Method (Year One)
P183	Digitisingthe Workflow for Construction Materials Test Data (Year One)
P184	Investigation of Ageing Behavioursof Binders using Fourier Transform Infrared Spectroscopy (FT-IR) (Year One)

ASSET MANAGEMENT AND HEAVY VEHICLES

A44	Synthesis and Dissemination of Best Practice and Value Asset Preservation and Management Strategies Sealed Roads (Year Four)
A61	New Generation iPAVe: Optimisingits use for Road Asset Management, Stage 1 (Year Two)
A63	ITS Pole Structural Inspections Guidelines Creation (Year Two)
A67	Network Lifecycle Model for Embodied Carbon and Emissions (Stage 1)
A68	Impact Assessment of the Introduction of Low and Zero Emission Heavy Vehicles on Road and Transport Infrastructure
A69	Roughness Test Loop in Qld (and other distress types)
R139	Project Proposal Low and Zero Emission (LZE) Pavement Evaluation and Modelling (Year Two)

STRUCTURES

S62	Management of Structures with Concrete Halving Joint-Scale Model Testing Project (Year Three)
S63	Buried Metal Culverts –Implementation of Remedial Options (Year Two)
S64	Revision and Updating of TN03 (Year Two)
S70	Implementation of Learning on Multiple Projects (Year One)
S71	Highly Skewed Bridges
S72	Review and Restructure of Non-Timber Bridge Repair Manual
S73	Navigating Sustainability for Structures

ROAD SAFETY

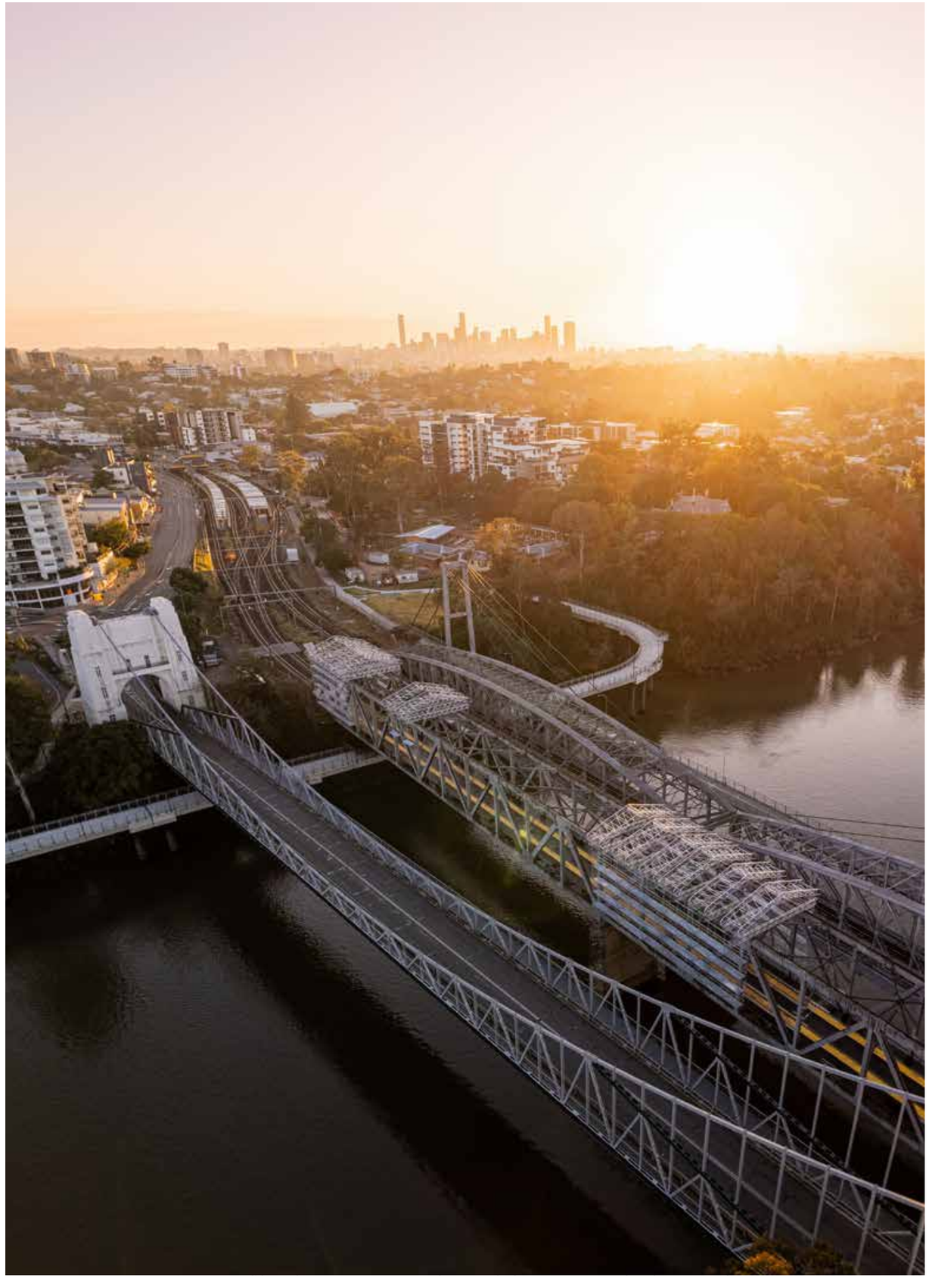
R144	110km/h Speed Limit Guidance on Queensland Roads and Motorways
R145	Guidance and Warrants and Justifications for the Installation of Raised Platforms at Signals
R146	The Appropriateness of Using Solid Lines Between Lanes (on roads with three or more lanes)
R148	Speed Reductions at Signals
R149	Geometric Considerations at Traffic Signals

NETWORK OPERATIONS

R100	TMR Traffic Data Access Portal (Year Five)
R136	Designing New Approach for Annual Average Daily Traffic Estimation (Year Two)
R137	Routine Maintenance (RMPC) ITS & Electrical Work Activities Review
R142	Network-level Active Transport Data Availability and Integrity (Year One)

SUSTAINABILITY

O28	Recycled Materials Supplier Database (Year Two)
O31	Regulated Waste Reduction Through Recycling Paint Wash Water and Raised Pavement Markers (RPM)
O36	Use of Limestone Cement in Stabilisation
O37	Railway Ballast
P117	Sustainability Assessment Tool (Year Five)



BENEFITS OF NACOE

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

NACOE continues 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
- Reducing the thickness of heavy-duty asphalt pavements, which 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 the use of recycled vehicle tyres in sprayed seals and asphalt
- Leading the way in the technologies that enable the 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 enhanced 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

NACOE's research has not only focused on economic and sustainability benefits but also on safety. The program has provided valuable guidance toward reducing crash risks on Queensland roads, a crucial aspect of road management. This emphasis on safety underscores NACOE's commitment to the well-being of the community.

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

PROGRAM IMPLEMENTATION

An important objective of NACOE research is to facilitate the implementation of new knowledge into practice.

KEY OUTPUTS OF THE NACOE RESEARCH PROGRAM WERE IMPLEMENTED THROUGH:

- The development of technical notes and design guide improvements
- The development of technical specifications
- Implementation through field trials and demonstration projects
- The dissemination of learnings through presentations, seminars, and webinars
- The preparation and presentation of technical papers at industry events
- Validation of existing practice through data gathering and analysis.

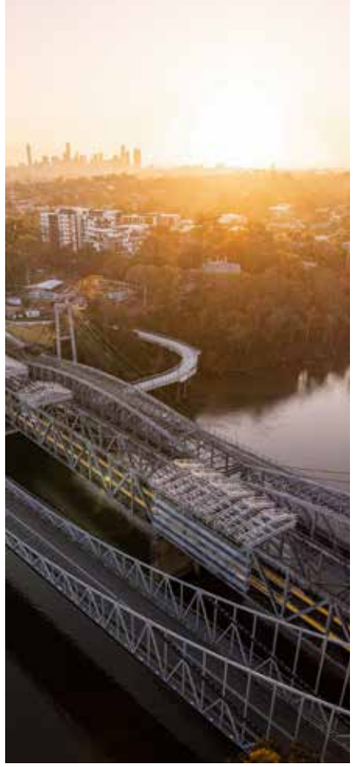
Research is delivered using a range of strategic research methodologies, each one meticulously designed to ensure the highest quality of outcomes, including:

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

CAPABILITY DEVELOPMENT

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

- Workshops that provided an enhanced understanding of the performance of Queensland's sprayed seal network
- Technical guidance and fact sheets to assist practitioners with the application of suitable countermeasures on narrow, sealed roads
- Several IC knowledge-sharing presentations and initiatives including a road map plan for industry stakeholders to:
    - Define different phases for the use of IC to assist with future forecasting and ensure the necessary equipment, software packages, trained personnel and resources for successful on-site IC project implementation
    - Demonstrate the benefits of IC technology using benefit-cost analysis (BCA) for road authorities to consider the bigger picture and whole life cycle costs
    - Benefit from the knowledge sharing of practical findings from the IC field trials, including training videos for the ease of use of the Veta 7.0 package for IC data display and analysis
- Guidance and tools to support a comprehensive, risk-based framework to help assist in funding allocations of different asset elements
- The development of a new Technical Note: Managing Dispersive and Slaking Soils on Infrastructure Projects
- The publication of 193 reports, presentations, and papers from 2013 to 2023, which are available on the NACOE website
- The delivery of 49 online webinars between 2019 and 2024, which are published on the NACOE website and YouTube.



INNOVATING GREENER, SMARTER ROADS

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 to create more opportunities for further road projects to be constructed.

THE MAJOR OUTCOMES FROM THE NACOE PAVEMENTS PROGRAM IN 2023 - 24 INCLUDED:

- Continuing development of performance-based evaluation protocol for standard and non-standardgranular pavement materials
- Intelligent construction technology for better roads in Queensland
- The use of Off the Road (OTR) tyre rubber in asphalt and spray seals
- Developing a laser texture depth method as an alternative to the sand patch method
- Increasing knowledge to inform updating specifications, based on the review of world's best practice and laboratory research
- Streamlining the use of recycled materials and recycled material blends for unbound granular pavement layers
- Transferring knowledge towards an increased use of recycled materials in bituminous products across the network
- A strong focus on industry and university collaboration across many pavement research projects

P166 – YEAR 1

Synthesis and Dissemination of Research Findings and Implementation Concepts for Pavements and Sustainability

IN 2024, NACOE HOSTED A FOUR-PART WEBINAR SERIES AIMED AT DISSEMINATING KNOWLEDGE FROM KEY PROJECTS TO TECHNICAL STAFF WITHIN TMR AND NTRO.

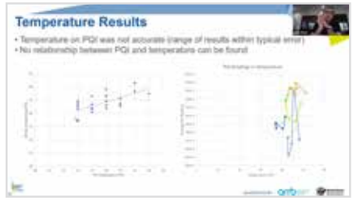
These webinars focused on relevant topics within the field of pavement engineering, providing valuable insights and fostering collaboration. The series commenced with a webinar on Intelligent Construction. This session explored the transformative potential of emerging technologies in construction practices, highlighting projects that have successfully implemented quality assurance measures, intelligent compaction techniques and PQI testing.

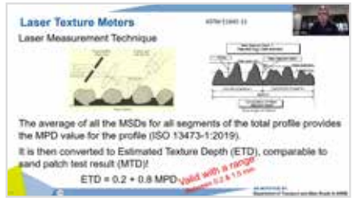
The second webinar delved into the topic of Rehabilitation, featuring presentations on innovative methods for extending the life of road infrastructure. Attendees learned about advanced quality assurance techniques and the latest advancements in pavement rehabilitation research.

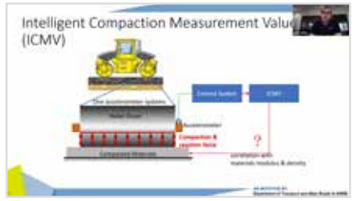
The third webinar focused on Sustainability discussing the impact of climate change on Queensland's infrastructure. The webinar covered NACOE's research on mitigating climate change through sustainable practices and adapting infrastructure to withstand future climate effects.

The final webinar in the series addressed Recycled Materials, providing insights from a decade of NACOE's research on sustainable construction materials and providing guidance on best practices for using recycled materials such as RAP, crumb rubber and recycled plastic.

All webinars included interactive Q&A sessions, allowing attendees to engage with NACOE experts and gain further clarification on the presented topics.







TOP & BELOW: Sam Afkar delivering project insights via a webinar (Sam Afkar, 2024).

P134 – YEAR 5

Development of Performance-Based Evaluation Protocol for Non-Standard Granular Pavement Materials

NON-STANDARD GRANULAR PAVEMENT MATERIALS PLAY A CRUCIAL ROLE IN THE CONSTRUCTION AND MAINTENANCE OF QUEENSLAND'S STATE-CONTROLLED ROAD NETWORK, PARTICULARLY IN RURAL AREAS WHERE STANDARD HIGH-QUALITY AGGREGATES ARE NOT READILY AVAILABLE.

The ongoing development of a performance-based evaluation protocol is essential to ensure these unbound granular materials can be reliably used in pavement applications. By establishing a consistent assessment framework, NACOE has been researching to expand the use of non-standard materials provided they satisfy the evaluation protocols – ultimately providing fit-for-purpose solutions that are cost-effective and sustainable, while maintaining the performance required for long-term road durability.

Over the past year, NACOE has been working on evaluating the physical and mechanical properties of several non-standard materials using a range of laboratory testing. The project assessed the relative performance of non-standard materials under each adopted experiment tested at different moisture conditions. The non-standard materials showed relatively superior performance at dry conditions. However, increasing moisture levels generally led to instability and significant changes in their performance, highlighting their moisture sensitivity. Research to date has shown that the performance of non-standard materials varies across different laboratory experiments. Nevertheless, a consistent correlation appears to exist between the modified Texas triaxial (MTT) test and the California Bearing Ratio (CBR) test when comparing the performance of different materials across laboratory testing.

This year, the project also focused on the use of the extra-large wheel tracking (XL-WT) test to assess the deformation potential of two non-standard materials under different moisture contents. The XL WT test will continue with additional materials to improve the quantity of information. Findings from this assessment will enhance the understanding of deformation characteristics of non-standard materials and could potentially assist in providing a more reasonable ranking of different non-standard materials in terms of likely in service performance. Later stages of this ongoing project will expand testing and aim to develop a performance-based non-standard material screening tool to assist in material selection and assessments for road pavement construction and maintenance.

This ongoing project delivers significant benefits by evolving TMR's knowledge for selecting non-standard pavement materials, thereby informing more reliable decision-making processes. By doing so, it reduces material costs, carbon emissions and waste disposal, while also minimising user delays, safety risks and unplanned expenses related to early road interventions. Furthermore, it promotes innovation within the production and construction sectors, expands material sourcing options in remote areas, and helps preserve limited natural resources, making it a sustainable and practical solution for the long-term management of Queensland's road infrastructure.

TOP & BELOW: Rural Queensland Road (Ian Steele, n.d).

P139 – YEAR 3

Slopes – Development of Wireless Sensor Network to Predict and Prevent Rainfall-Induced Landslides

IN ITS THIRD YEAR, NACOE'S P139 PROJECT HAS WORKED TO ESTABLISH A WIRELESS SENSOR NETWORK DESIGNED TO FORECAST AND PREVENT LANDSLIDES INDUCED BY RAINFALL.

This reliance network will utilise cutting-edge sensors to provide real time data on soil moisture and slope movements during and after precipitation. Constructed using silicon and silicon carbide microsensor technology developed by Griffith University, these sensors will allow the mass production of highly sensitive, low-power, cost-effective, and sturdy intelligent network infrastructure. Integrating this sensor technology with state-of-the-art IoT wireless communication technology will create a durable, energy-efficient, and expansive landslide sensor network.

Deployed along susceptible roadside slopes, the network, consisting of tens of thousands of sensor nodes, will furnish instantaneous information on soil moisture and soil movement and early warnings of landslides. This data will not only assist in the management and regulation of traffic but will also contribute to significant cost savings, thereby mitigating both human and economic losses.

Project deliverables will encompass a comprehensive literature review report, laboratory testing, and sensor development. This initiative's projected advantages, including the provision of real time soil moisture and soil movement data, the issuance of early landslide warnings, and support for the TMR District office in its decision-making process regarding road closures, will enhance the effectiveness of TMR's work in managing infrastructure and disaster situations.

TOP: Landslides and storms close Gold Coast hinterland road (Shutterstock [SS] 2193536381). **BELOW:** Landslide on Captain Cook Hwy after Cyclone Jasper (SS 2446967401).

P179 – YEAR 1

Intelligent Construction Technology for Better Roads in Queensland

Intelligent Construction Technology has been emerging as a significant shift in Queensland's road industry, addressing the growing demand for more accurate road construction methods. This approach combines advanced technologies to measure, display, and record pavements precisely and efficiently ultimately leading to improved long-term cost benefits.

Key components of Intelligent Construction include Intelligent Compaction (IC), Thermal Profiling, and Dielectric Profiling Systems (DPS). These technologies offer substantial benefits, such as improved compaction uniformity, real time data collection, and more comprehensive construction records. This move towards smarter construction methods promises to deliver roads that are not only better built but also more resilient to Queensland's diverse environmental conditions.

Building on several years of research since 2019, NACOE has continued its work in this space with the first year of a new project focusing on implementing these technologies.

A key achievement this year has been the update of specifications and the creation of customised technical notes to support the implementation of IC. We've also developed additional training materials to ensure our workforce is well-equipped to utilise this technology. To broaden understanding and adoption, we've conducted information sessions for both district offices and industry practitioners, particularly contractors who'll be at the forefront of using this technology.

Our work this year has encompassed a wide range of tasks, from project management to on-site IC support. We've closely monitored IC projects to define detailed specifications for project control and acceptance. In addition, we've made progress in trialling thermal profiling technologies, as well as 3D milling techniques.

We've also initiated a feasibility study for the use of DPS in Queensland, exploring its potential to enhance our road construction quality assessment. Throughout the year, we've maintained a focus on stakeholder engagement, holding webinars, workshop sessions, and technical seminars to ensure our innovations meet the needs of all parties involved in road construction and maintenance.

TOP & MIDDLE: Flinders Highway- March 2023 (Sam Afkar, 2023). **BELOW:** AfPA Qld Award- June 2023 (Sam Afkar, 2023).

P132 – YEAR 3

Queensland's Foamed Bitumen Mix Design and Structural Design Procedure: Review and Improved Methods

THIS YEAR, NACOE CONTINUED ITS RESEARCH INTO FOAMED BITUMEN STABILISED (FBS) PAVEMENTS, BUILDING ON OUR PREVIOUS FINDINGS AND EXPLORING NEW AVENUES FOR IMPROVEMENT.

We've made significant strides in understanding the performance of these materials under various conditions, which will inform future road construction and rehabilitation projects across Queensland and beyond. This year's research focused on investigating the impact of varying field conditions based on laboratory testing and FBS material performance evaluation. We conducted extensive testing, including:

1. **Flexural beam tests to evaluate the effects of temperature and loading speed**
2. **XL-WT (Extra Large Wheel Tracker) testing to better simulate real-world conditions**

Key findings from this research revealed that FBS materials showed less sensitivity to temperature and loading speed than previously assumed. These findings could lead to more accurate modelling and design of FBS pavements. We also found that the fatigue life of FBS materials decreased by fivefold between 20°C and 35°C – a significant reduction but less significant than earlier studies suggested. Interestingly, XL-WT testing yielded longer fatigue life predictions compared to traditional flexural beam testing, likely due to its closer simulation of field conditions.

Moving forward, we recommend further consolidation of temperature and loading speed effects on FBS materials, exploration of XL-WT testing as an alternative fatigue testing method (with improved strain measuring techniques), and continued calibration of laboratory results against real-world performance monitoring. This research was recently highlighted at the AustStab awards. NACOE researchers Damian Volker (TMR) and Dr Didier Bodin (NTRO) won the prestigious AustStab Award for their highly commended research into the 'Performance of Foamed Bitumen Stabilised Materials under Laboratory Simulated Field Conditions.' The rollout of this research will provide sustainability benefits to all projects that use TMR's technical documents.

This research represents a significant step forward in our understanding of FBS pavements, and will inform future design standards and performance-based specification practice across Queensland, ultimately leading to more resilient and cost-effective road infrastructure.

TOP: Dr. James Grenfell, Damien Volker, and Dr. Didier Bodin at AustStab Awards 2024. **BELOW:** Process of asphalting blacktopping and paving asphalt paver machine (SS 2033430674).

P168 – YEAR 1

Improved Resilience of Unbound Granular Pavements

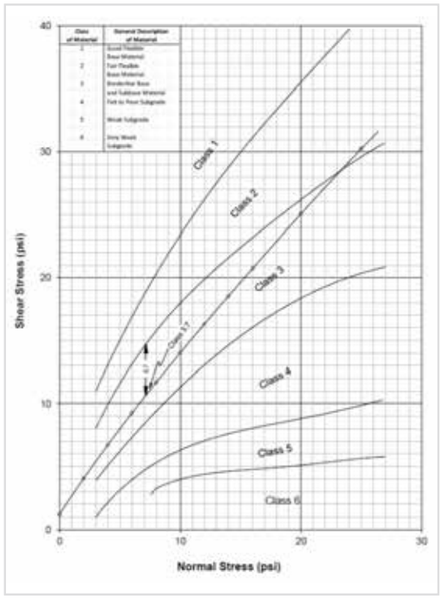
MUCH OF AUSTRALIA'S ROAD NETWORK COMPRISES UNBOUND GRANULAR LAYERS WITH A THIN BITUMINOUS SEAL, SERVING AS A COST-EFFECTIVE ALTERNATIVE TO TRADITIONAL CONCRETE AND ASPHALT PAVEMENTS.

These pavements' structural integrity and bearing capacity are crucial for their long-term performance, especially in light of recurring traffic loading and varying environmental conditions. Pavements designed in accordance with existing Australian Structural Design of Road Pavements standards are experiencing permanent deformation due to increased traffic volumes and variability in material sources. The existing design methodology, which relies on empirical relationships developed in the 1930s, focuses on assessing aggregate quality based on construction and material specifications. However, a comprehensive understanding of the performance of unbound granular materials beyond material property specifications is essential for enhancing overall pavement performance and accommodating sustainable materials.

TMR currently utilises Repeated Load Triaxial (RLT) and wheel tracker testing methods to assess unbound materials. Nonetheless, these methods are being investigated for their relevance and application to increasing impacts from climate change. Consequently, as part of the NACOE project P168, Improved Resilience of Unbound Granular Pavement, TMR requested a thorough review of methodologies and protocols for evaluating the performance of unbound granular materials. To ensure world-leading best practices were identified, NACOE conducted thorough documentation of the findings from the literature review, followed by an examination of historical data to establish improved laboratory performance evaluation methods.

Additionally, rigorous evaluation of unbound granular materials laboratory testing explored the application of various testing methodologies, including RLT, Wheel Tracking (WT), CBR, Pavement Underbody Measurement Apparatus (PUMA) and accelerated pavement testing, to assess material performance and rank them. The ongoing research emphasises that the primary damage caused by repetitive traffic loads is rutting and permanent deformation and highlights the necessity of a performance framework to pre-screen granular materials for road pavements before undergoing detailed and often costly pavement performance testing.

The primary objective of this project is the development of a comprehensive protocol for assessing the performance of unbound pavement materials, which has considered an extensive review and comparison of national and international processes and protocols to establish robust evaluation methods.



TOP: Accelerated Loading Facility (ALF) at the Dandenong site, Victoria, 2024. **BELOW:** TEX 117-E Classification chart.

P167 – YEAR 1

The Use of OTR Tyre Rubber in Asphalt and Spray Seals

USING CRUMB RUBBER DERIVED FROM ON-THE-ROAD VEHICLE TYRES, PARTICULARLY PASSENGER VEHICLES AND TRUCKS, IS A CUSTOMARY PRACTICE FOR FABRICATING CRUMB RUBBER MODIFIED BINDERS (CRM) USED IN SPRAYED SEALS.

These bituminous binders have increasingly been employed in Australian spray sealing and asphalt in the last several years. Despite on-the-road tyres constituting around 77% of the end-of-life tyres generated in Australia, off-the-road (OTR) tyres still represent a notable proportion, approximately 23%. OTR tyres encompass specialised mining, agricultural, construction, manufacturing and aviation tyres, with the mining and farming sectors contributing to roughly 95% of the total 113,000 tonnes in 2019–20[1]. A minority of end-of-life OTR tyres, notably less than 14%, are subjected to reuse, with 93% of mining OTR tyres and 90% of agriculture OTR tyres being disposed of on-site. The predominant disposition method involves burial on-site, dumping, or landfilling, presenting a prospective opportunity to advocate for expanded utilisation within road construction.

The recycling of certain types of OTR tyres is purportedly restrained due to practical challenges related to the handling, transportation, storage and processing of oversized tyres and the remote or fragmented nature of sources/generators of specific end-of-life OTR tyre types. While Austroads and TMR standards do not prohibit OTR tyres' implementation in CRM binder production, there is limited research validating their efficacy, whether as stand alone crumb rubber products or when blended with crumb rubber from other tyre types.

This NACOE project is a promising initiative that examines and compares OTR CRM bituminous binders with the properties of on-road tyre CRM binders. The project, with a specific emphasis on compliance with prevailing specification requirements and binder grades, particularly in the context of the sealing grades, seeks to enhance the recycling rate of OTR tyres. This effort directly supports an industry-led OTR CRM binder demonstration field trial at Peak Downs Highway, which will be implemented on TMR's network in 2022–23. The Australian Flexible Pavement Association (AfPA) has orchestrated the supply of OTR CRM bituminous binders and provided technical assistance for the demonstration field trial under the TMR-AfPA Strategic Alliance.

This research harmonises with various regulations, strategies, and partnerships related to waste management. It corroborates existing research and regulations concerning tyre recycling and waste management, reassuring stakeholders about the project's relevance and importance.

The engagement associated with this project is comprehensive, including industry outreach, literature review, laboratory testing, and thorough documentation and dissemination. Laboratory assessments have scrutinised the attainable material properties from a 100% OTR tyre-crumbed rubber source, complementing the tests conducted in the industry-conducted field trial. This thorough approach instils confidence in the research and its potential impact.

[1] Tyre Stewardship Australia (TSA), 2020.

TOP: Landfill with old tyres and tyres for recycling (SS 2020571027).

P144 – YEAR 1

Development of Laser Texture Depth Method to Replace Sand Patch Method

LASER-BASED TEXTURE MEASUREMENT INSTRUMENTS OFFER THE POTENTIAL FOR A FASTER AND SAFER ALTERNATIVE THAN EXISTING INDUSTRY STANDARD SAND PATCH TECHNIQUES, WITH THE POTENTIAL FOR IMPROVED ACCURACY, CONSISTENCY AND EFFICIENCY.

NACOE's P144 project evaluates laser-based instruments for measuring road surface texture as a potential substitute for the manual sand patch method. The main objectives included.

- **Identifying suitable instruments.**
- **Developing a test method.**
- **Suggesting changes to technical specifications to promote the adoption of laser surface texture measurements.**

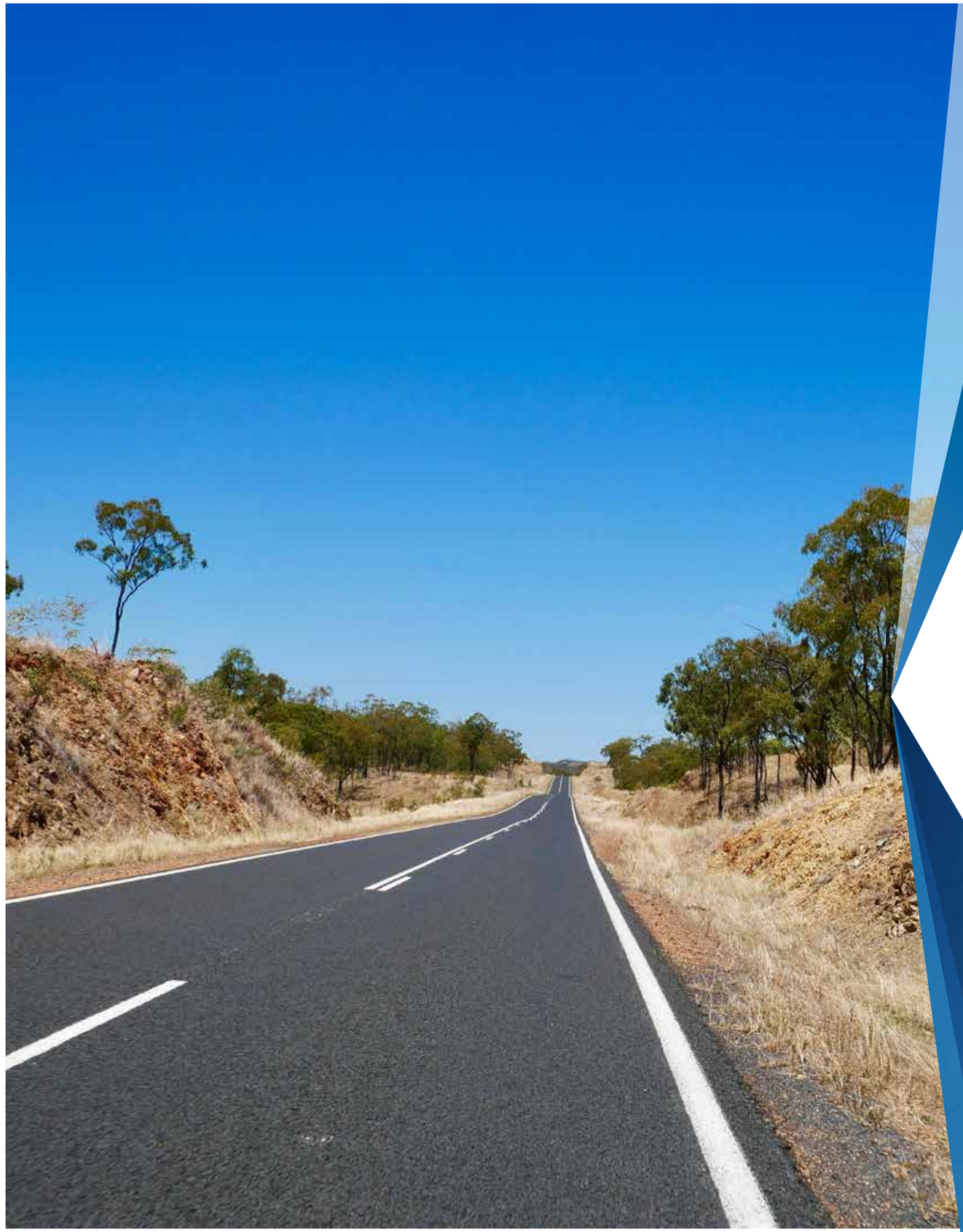
Research began with a review of existing knowledge and industry best practices related to measuring surface texture, focusing on handheld and portable laser-based devices suitable for measuring surface texture. Among the devices reviewed, the ELAtextur laser scanner, already used by certain operators in Queensland, produced highly comparable results to the sand patch method for smoother surfaces such as asphalt and concrete. However, the correlation is less reliable for higher textured surfaces such as sprayed seals and exhibits more variability.

Field trials were conducted to assess the capabilities of the ELAtextur in measuring surface texture compared to the sand patch method across various surfaces. While the ELAtextur device demonstrates high repeatability, there are ongoing queries regarding its ability to accurately capture overall texture characteristics due to its singular circular profile measurement. The ELAtextur provides highly reliable results for asphalt and concrete surfaces but exhibits more scatter and typically underestimates surface texture for higher textured sprayed seals. An equation has been proposed to adjust the ELAtextur's output, providing a better estimation of the sand patch method for surface texture depth for sprayed seals.

Despite the scatter in measurements, the ELAtextur device demonstrated high repeatability, while the sand patch method displayed some variability. Additionally, the ELAtextur typically reports a surface texture lower than the sand patch. An equation has been proposed to convert the ELAtextur's output into an estimated surface texture depth for sprayed seals, which is more likely to deliver an accurate result than the raw outputs of the device. The default ELAtextur outputs closely matched the sand patch measurements for asphalt and concrete surfaces.

This report's detailed analysis and findings underscore the potential of laser based instruments as a feasible and promising alternative to the traditional sand patch method for measuring road surface texture. If realised, this potential could significantly improve road maintenance operations' efficiency and safety.

TOP: Sand Patch Test Method (White et al.(2021).
BELOW: ELAtextur device fitted to its trolley.



DRIVING PROSPERITY FOR QUEENSLAND

Asset Management and Heavy Vehicles

The NACOE Asset Management and Heavy Vehicles 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, the underlying assumptions within these models, and their application as part of continuous business improvement.

THE STREAM DELIVERS 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
- Transferring knowledge in asset management to deliver benefits and enhanced practices across Queensland and Australia. The program also has a strong focus to collaborate with industry and universities
- A growing focus on asset management sustainability and electric heavy vehicles

A comprehensive list of Asset Management and Heavy Vehicles projects undertaken in 2023/2024 are listed on page 5 of this report. Several other projects produced outputs for the sole purpose of guiding TMR and remain unpublished

A67 – YEAR 1

Network Lifecycle Model for Embodied Carbon and Emissions

THE NACOE PROJECT A67 PLAYS A CRUCIAL ROLE IN ADDRESSING THE DISPARITY BETWEEN THE ATTENTION GIVEN TO THE EMBODIED CARBON EMISSIONS ASSOCIATED WITH NEW INFRASTRUCTURE PROJECTS AND THOSE GENERATED DURING THE ESSENTIAL MAINTENANCE AND PRESERVATION OF EXISTING INFRASTRUCTURE AND ASSETS.

When considering a pavement's life cycle, analysis has shown that maintenance emissions can often exceed the initial construction emissions. The most significant component of a pavement's total life cycle emissions is attributed to enabled emissions, that is, the emissions associated with the fuel consumed by vehicles using the road. This underscores the importance and relevance of being able to estimate these emissions and understand their impacts under different maintenance regimes.

In the context of the push toward net zero emissions, the Government's imperative to comprehend the implications of maintenance treatments in embodied and enabled carbon emissions is highlighted. This project not only aims to address the existing knowledge gaps around embodied and enabled emissions, but also has the potential to reduce network carbon emissions significantly. By informing the estimated emissions using multiyear life cycle analysis, road asset owners and network operators, such as TMR, can develop more sustainable maintenance and preservation programs. This research project draws on NACOE's capabilities to accurately predict road deterioration, post-maintenance resets, and associated road user and fuel consumption and costs, which are paramount for discerning and quantifying variances in treatment strategies, programs, and budgetary levels, and will align with TMR's pavement life cycle tools.

LEFT: GHG emissions produced by the '35AC10' (left) and '50AC14' (right) treatments. **TOP:** Top view of architectural engineer working on construction site (SS 2063920685).

A68 – YEAR 1

Impact Assessment of the Introduction of Low and Zero Emission Heavy Vehicles on Road and Transport Infrastructure

THIS YEAR, NACOE CONTINUED ITS PROJECT TO INVESTIGATE THE PAVEMENT IMPACTS OF LOW AND ZERO EMISSION (LZE) HEAVY VEHICLES WEIGHING OVER 4.5 TONNES. AS THE TRANSPORTATION SECTOR EVOLVES TOWARDS MORE SUSTAINABLE SOLUTIONS, IT IS ESSENTIAL TO UNDERSTAND HOW THESE VEHICLES WILL AFFECT ROAD INFRASTRUCTURE.

NACOE has taken a comprehensive approach, examining not just the immediate impacts but also the long-term implications for maintenance, improvement costs, and network constraints. In the first stage of the research, NACOE focused on understanding the freight tasks these LZE vehicles will perform and their resultant pavement impacts. An extensive review of existing pavement impact models, considering both vertical and horizontal loading, was conducted. This initial phase also included a preliminary assessment of agency costs under various scenarios.

In the second year of the project, the scope is expanding. The pavement impact models will be extended to include analysis under budget constraints. This will provide a more realistic view of how agencies can manage the transition to LZE heavy vehicles within existing financial limitations. Additionally, the analysis is broadening to encompass a more comprehensive consideration of costs and benefits. This includes examining the impact on local pollutants, CO_2 emissions and other road user costs associated with specific freight tasks. By taking this holistic approach, TMR will be able to provide a more accurate whole-of-life picture of the overall impact of transitioning to LZE heavy vehicles.

The benefits of this research for Queensland are significant. It will provide a better understanding and quantification of potential maintenance and improvement costs associated with LZE heavy vehicles across the entire network. Network constraints will be identified, and potential treatment and mitigation strategies will be developed. Furthermore, this project will increase understanding of LZE heavy vehicle duty cycles and their projected uptake. This knowledge is crucial for planning future infrastructure needs and maintenance schedules.

TOP: Transportation trucks in high-speed driving on a highway through rural landscape (SS 2287775613).

BUILDING FOR RELIABILITY AND RESILIENCE

Structures

Significant investment has been made in the NACOE Structures stream in the last eight years. Over 30 projects have been delivered and several outcomes from completed projects have been implemented into TMR practice.

THE NACOE STRUCTURES STREAM HAS DELIVERED BENEFITS TO THE TRANSPORT INFRASTRUCTURE NETWORK TO DATE THROUGH:

- 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
- 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, factors that affect risk scores and risk score anomalies, how to use TMR's existing jacking monitoring system for bridge lifting, input into TMR's 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

S62 – YEAR 3

Management of Structures with Concrete Halving Joint-Scale Model Testing Project

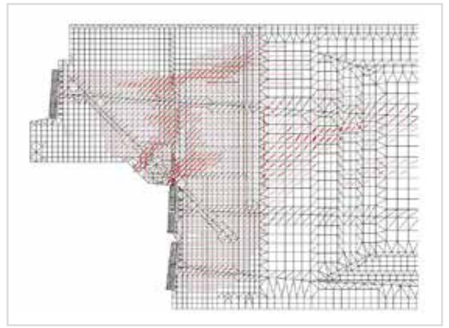
THE STRUCTURES WITH HALVING JOINTS CONSIST OF SUSPENDED SPANS WITH DAPPED ENDS SUPPORTED ON THE NIBS OF ABUTMENTS OR ADJACENT CANTILEVERED GIRDERS.

The physical configuration of the joint results in a sudden change in geometry, leading to substantial variation in the stiffness and strength within the joint section. While the joints are positioned and configured to minimise global bending moments, they typically exhibit significant cross-section shear, resulting in localised shear and bending due to the joint configuration. This reduced cross-section stiffness and strength, combined with complex localised bending and shear, renders them vulnerable to failure, often exacerbated by other factors.

Fifty-seven structures containing concrete halving joints have been identified within the TMR network. Halving joints are no longer permissible in new TMR bridge designs, but legacy structures are expected to remain in service for many years. Since design codes have evolved since these structural details were first introduced, many halving joint bridges are non-compliant with current code provisions. As part of the management of structures with concrete halving joints project (HJ project), TMR has scheduled a program of assessments and inspections to capture the existing condition, identify typical defects and issues related to these structures, and establish a proactive management regime.

The modelling of halving joint structures developed in Year 2 of the project has enhanced the understanding of their structural behaviour. In particular, the improved understanding of Lagoon Creek bridge concluded that the development length limitations are crucial and dominate the failure mode to the extent that the normally anticipated re-entrant corner failure mode has a significant margin available compared with the predicted (and previously unidentified) failure mode. While the existing relatively large re-entrant corner cracks are indicative of previously applied load, they are not particularly concerning based on this investigation.

While the capacity of these halving joints is likely higher than indicated by the preliminary strut-tie model, an improved estimate of capacity and behaviour would benefit from better quantification of strand development. Year 3 of the project was focused on developing an experimental program to determine the bond characteristics between strands and concrete, namely the development length and bond slip relationship, and, with statistically significant results, updating the Lagoon Creek model.



Researchers performed pull-out tests on 31 strands of different embedment lengths on two prestressed concrete girders samples that were made available for testing by Enco. The analyses undertaken using a bond model informed by the results of the strand bond testing showed that the failure will be controlled by yielding of the strand and not by slip of the strand. The response for the halving joint should be ductile with significant cracking and deflections occurring prior to failure. The critical crack location is still influenced by the halving joint reinforcing and is in the same location as previously advised, namely, just behind the termination of the diagonal reinforcing bars.

Further studies will focus on advancing durability research, particularly through more in-depth corrosion investigations. Additional efforts will be made to explore strand bond behaviour by restricting rotation during pullout tests. These findings will contribute to the development of a draft guideline for the inspection, maintenance, and assessment of halving joints, ensuring that the lessons learned from these studies are effectively incorporated to enhance best practices in structural asset management.

TOP: Concrete expansion joint in a road bridge (SS 2380501239).
BELOW: Typical halving joint FEA output showing crack directions.

S64 – YEAR 2

Ground Vibration and Air Blast Safe Practices Revision and Updating of TN03

IN 2023–24, NACOE HAS UNDERTAKEN A PROJECT TO REVISE AND UPDATE TMR'S GUIDELINES FOR GROUND VIBRATION AND AIR BLAST SAFE PRACTICES DURING CONSTRUCTION.

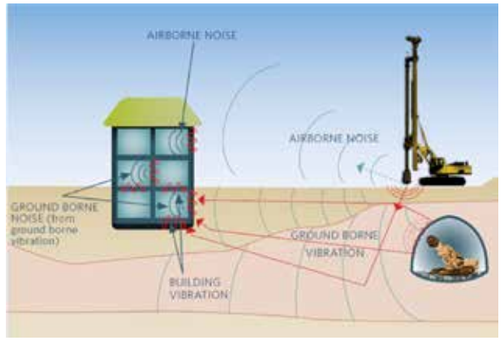
The current TN03 (published in 2013) provides guidance on:

1. **Permitted vibration limits on TMR structures due to construction-related vibration.**
2. **The minimum set back distances for vibratory rollers in controlling structural damage on nearby structures.**

NACOE identified an opportunity to update TN03 and its vibration limits for TMR structures. To address this, NACOE launched a multifaceted approach. The project encompassed a thorough literature review of existing guidelines, a detailed gap analysis of current practices, and field testing to verify recommendations. Based on this, considering both the transient and the continuous vibration, the maximum allowable Peak Particle Velocity (PPV) were recommended for TMR structures namely bridges, culverts, retaining walls and buildings.

Field testing was carried out with a range of vibratory and oscillatory rollers representing the current industry practice. The objective of the field testing was to generate a vibration data set for different rollers with two different fill materials and to identify the trends. The results are presented in terms of the maximum PPV and its relation to the roller weight, centrifugal forces and vibration amplitude. A comparison between the vibratory and the oscillatory roller PPVs shows that there exists a considerable advantage in minimising the vibration by using oscillatory rollers. Additionally, the vibration attenuation is determined to provide practical guidance on the set back distances between the rollers and the impacted structures.

The aim of TN03 is to provide a consistent and practical framework for managing construction-related vibrations across Queensland on lower risk projects. Predicting vibration and vibration-related damage (cosmetic or structural) is complex, and ongoing construction feedback will allow for the optimisation of the guideline, especially where novel construction methods are introduced.



TOP (3): Field trials in progress. **BELOW:** Diagram of Ground Borne Vibration (NZTA State highway construction and maintenance noise and vibration guide, 2019).

S67 – YEAR 2

Future Availability of Fly Ash for Concrete Production in Queensland

IN CONCRETE PRODUCTION, FLY ASH PLAYS A CRUCIAL ROLE AS A SUPPLEMENTARY CEMENTITIOUS MATERIAL (SCM), ENHANCING DURABILITY AND COUNTERING ALKALI-SILICA REACTION (ASR).

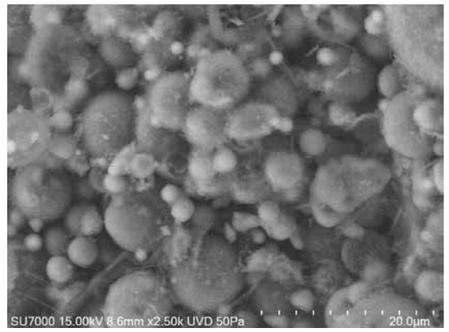
Queensland's coal-fired power stations have been the primary source of fly ash for the state's concrete industry. However, there is increased demand for both fly ash use and alternative energy and this has created an urgent need to identify alternative fly ash sources. TMR is particularly invested in this search, as fly ash is a key component in the concrete used for its infrastructure projects.

The research focused on two main objectives: determining the future production and usage profiles of fly ash sourced from Queensland power stations, and investigating alternative options to current fly ash supplies with laboratory testing. A literature review was conducted alongside insights from members of the concrete and cement industry. The primary goal of the project was to comprehend the anticipated availability of fly ash, as well as potential alternative materials for future use in TMR projects.

Key findings indicate that run-of-station fly ash will likely be available until 2040, but alternatives will be required beyond that time. Several potential replacements were identified, including agricultural solid waste, ground granulated blast furnace slag, and various mineral additives. Each option presents unique opportunities and challenges that will continue to be evaluated.

Among the alternative sources reviewed, ponded fly ash from dams was recognised as one of the most feasible options. It is estimated that over 250 years of ponded fly ash may be reclaimed at the current consumption rates, subject to the quality and composition of material at individual sites. The research program was therefore extended to undertake laboratory testing of ponded fly ash samples collected from dams in Queensland, to further check the required properties.

While further research is required to determine the caveats of use, overall, the ponded fly ash in the Queensland ash dam appears to be a promising alternative for fresh fly ash in various civil engineering applications, including concrete manufacturing, beyond the year 2040.



TOP: Fly ash coal waste used for concrete (SS 1934812655).
BELOW: SEM image of ponded fly ash.

S73 – YEAR 1

Navigating Sustainability for Structures

THE QUEENSLAND GOVERNMENT HAS SET A TARGET OF ACHIEVING NET ZERO EMISSIONS BY 2050.

To support this goal, NACOE's S73 Project, Navigating Sustainability for Structures, has been established. This project aims to research and advise on activities to help TMR reduce carbon emissions from road transport structures, such as bridges and culverts, while enhancing overall sustainability.

The project focuses on exploring opportunities related to sustainable materials with a focus on low carbon concrete and embodied carbon estimation and assessments, and implementing initiatives to reduce emissions. The project prioritised to provide insights into methods for significantly reducing the carbon footprint of TMR's structural assets through data-driven planning, design and monitoring. These considerations enable the adoption of sustainability strategies best practices for constructing and maintaining the assets throughout their lifecycle.

The project also developed an Innovation Assessment to evaluate products and solutions that claim sustainability benefits. This practical methodology led to several key findings, particularly in the area of concrete decarbonisation technologies. The project assessed existing and emerging technologies, their technical and market maturity within Queensland, as well as TMR's capacity to implement these technologies. One major finding was that immediate carbon reductions can be achieved through increasing the use of high supplementary cementitious materials and geopolymer concretes in precast concrete manufacturing.

Moreover, the project scrutinised the quality of available data sources for estimating material quantities and embodied carbon for TMR's structures, focusing on concrete, reinforcing and structural steel, and structural timber. The assessment indicated that, while TMR generally has access to high-quality material type and quantity data, the embodied carbon factors are low to medium quality.

Lastly, the project provided clarity when defining sustainability in design, giving practitioners strategies for integrating sustainability considerations into the design of structures. This guidance aims to help designers incorporate sustainability measures, criteria, and sustainable practices and outcomes into their designs.

TOP: Glorious sunset over Decker Park and Hornibrook bridge at low tide in Clontarf Queensland Australia (SS 2410864105).

DELIVERING SAFER JOURNEYS

Road Safety

Safety is paramount in Queensland's transport network. Over the past decade, the NACOE Road Safety stream has exemplified this commitment. Dedicated to safeguarding every road user across every journey, we've identified and employed innovative technologies and proactive strategies.

NACOE'S ROAD SAFETY SUBPROGRAM HAS SOUGHT TO DELIVER BENEFITS TO THE NETWORK IN SEVERAL WAYS:

- Reducing crash risk at roadworks sites
- Protecting the public at short-term roadworks sites
- Identifying effective traffic control devices
- Proactive approach to roadside safety
- Wide centreline effectiveness evaluation
- Researching high-risk crashes
- Streamlining traffic management
- Investigating new and emerging technology solutions in road safety
- Automating data collection for risk assessment models

R149 – YEAR 1

Geometric Considerations at Traffic Signals

R149 FOCUSED ON ANALYSING ROAD DESIGN CONSIDERATIONS, SPECIFICALLY THE LONGITUDINAL GRADIENTS AND OTHER GEOMETRIC FACTORS AT SIGNALISED INTERSECTIONS WITH STEEP GRADES.

The project aimed to understand the safety implications, particularly at the approaches to these intersections. Key findings from both Australian and international studies highlighted the importance of managing these approach grades and the effect of uphill and downhill gradients on road safety, with particular attention to heavy vehicles and vehicle speeds. The report also explored design measures from existing literature to address challenges such as heavy vehicle manoeuvrability, speed compliance and critical safety concerns like stopping sight distance and dilemma zones at steep-grade intersections.

The project originated from concerns about the safety implications of intersections, particularly where steep approach grades made traffic signals potentially unsuitable. The project involved researching acceptable maximum grades for signalised intersections, taking into account various design and road safety factors to assess the feasibility of installing signals on steeper grades. The literature review concluded that while traffic signals may be implemented on steeper grades, specific mitigation measures are required to address safety concerns, particularly related to heavy vehicle operations and speed management.

ABOVE: Aerial imagery of Dalton Road intersections.

DATA-DRIVEN SOLUTIONS FOR SMARTER ROADS

Network Operations

Since its inception, NACOE's Network Operations stream has consistently delivered a substantial return on investment through benefits to TMR and the Queensland transport network. For over a decade, this future-focused research team has identified network best practices globally and applied them to Queensland roads to optimise how we use and understand our road network.

SIGNIFICANT OUTCOMES OF THE NACOE NETWORK OPERATIONS STREAM BETWEEN 2023–24 INCLUDE:

- Updated guidelines and audit procedures for effective heavy vehicle interception sites
- Methodology development for quantifying the economic impact of congestion on multimodal travel for the Bruce Highway Managed Motorway Project
- Assessment of emerging technologies in monitoring and enforcing compliance with road-friendly suspension regulations
- Revised TMR guidance documents for addressing head-on, run-off-road, and intersection crashes
- Methodology development for accurately quantifying the economic costs of excessive congestion on freeways and arterial roads
- Feasibility assessment of telematics technology for effectively communicating critical messages to drivers
- Development of real time assessment system of spare capacity on road networks
- Enhanced understanding of freight movement patterns in Queensland through the implementation and analysis of virtual weigh-in-motion data
- Evaluation of potential energy-saving measures for road operations infrastructure
- Updated design and development practices to enhance accessibility for people with disabilities across the transportation network

R100 – YEAR 5

TMR Traffic Data Access Portal

IN 2023–24, NACOE MADE SIGNIFICANT STRIDES IN ITS MISSION TO PROVIDE EFFICIENT, USER-FRIENDLY ACCESS TO QUEENSLAND'S TRAFFIC DATA.

The project identified stakeholder requirements for a HERE Traffic Analytics data access portal and user-friendly web interface. The portal leverages Amazon Web Services (AWS) technologies to host and manage traffic data in a cost-effective and scalable manner.

This initiative has continued to evolve, building on the robust foundation established in previous years. Over the course of the year, enhancements have focused on improving user experience, expanding functionality and ensuring seamless integration with TMR's existing systems.

One of the challenges to solve was that the HERE traffic data in its native downloaded form was difficult to access and lacked instantaneous retrieval and aggregation reporting without data manipulation and GIS capabilities. Year 5 focused on the continued improvement of the traffic portal in these areas, which will help in having reliable traffic data reports and up-to-date data readily available for access. The preservation of routes after map updates will also help in swift movement from one map version to another.

NACOE ACHIEVED SOME MAJOR MILESTONES THIS YEAR, INCLUDING:

- **Preservation of Routes:** Database flags have been introduced into the current map version table. New logic has been introduced into the system, so user-defined routes can be moved across different map versions automatically when required.
- **Increase of Data Ingestion Frequency:** The frequency of traffic data ingestion has been updated from once a week to three times a week to provide more recent traffic data to TMR users.
- **Updating User Interface Peak Group:** These were updated from the front-end as well as back-end queries. Since the data, once ingested, creates a Structured Query Language view to classify which ones belong to which peak group, this view will now need to be re-created once the portal is updated.
- **Updating Monthly Reliability Report:** This is a continuation of Year 4 development activities where the monthly reliability report was introduced.

As a result of review and user feedback, some back-end improvements were initiated by TMR to get a more reliable and accurate output. Sufficient spatial and temporal data coverage is vital to support accurate reliability calculations. These business rules were important to remove scenarios such as small amounts of data contributing to greater reliability values.

Currently, in Year 6, NACOE is continuing to work on improving folder organisation for routes and spatial information extraction. The improvements made in the past year and the ongoing developments will ensure Queensland's traffic data is easily accessible and user-friendly.

TOP: Transportation and communication network concept (SS 2135682715).

R142 – YEAR 1

Network-level Active Transport Data Availability and Integrity

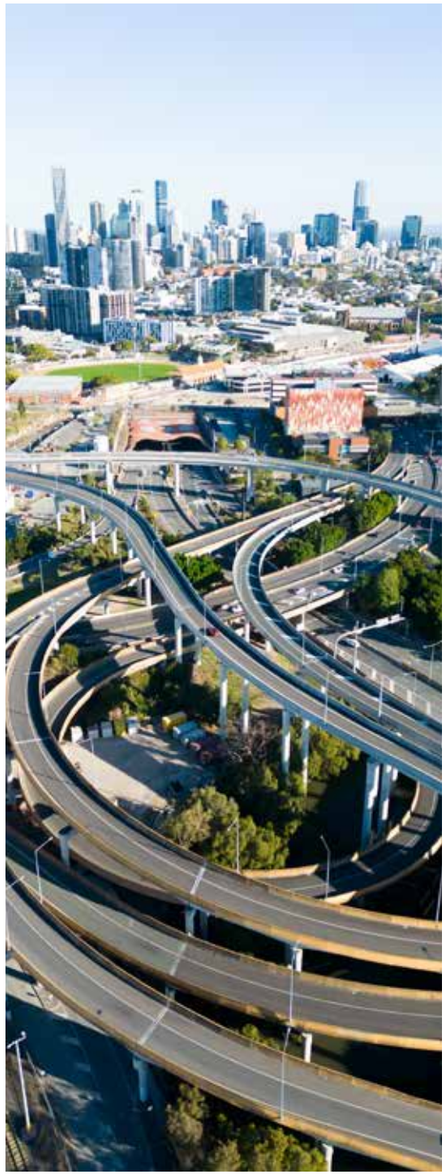
AS CITIES EVOLVE AND SUSTAINABLE MOBILITY BECOMES INCREASINGLY IMPORTANT, THE ROLE OF WALKING, CYCLING AND MICRO-MOBILITY IN THE TRANSPORTATION ECOSYSTEM IS GAINING PROMINENCE.

Data from Active Transport (AT) is critical for infrastructure planning and enhancing the efficiency, safety, and sustainability of transportation systems. This year, NACOE initiated a project to improve the availability and integrity of AT data across Queensland's network. The project focuses on conducting a review and gap analysis of AT data, with special attention to existing demand estimation models within TMR.

KEY FOCUS AREAS:

- **AT Counts Strategy Development:** A thorough requirement-gathering exercise was conducted to identify Queensland's needs and priority use cases for active transport counting. As a result, an AT counts data standard was developed, ensuring consistency in future data collection efforts across the state.
- **AT Infrastructure Mapping:** This phase of the project focused on mapping AT infrastructure. Discovery work was conducted to identify current and potential custodians of digital representations of AT infrastructure, laying the foundation for creating a unified digital AT network. A data standard for classifying AT infrastructure has been proposed, alongside an analysis of existing digital AT networks, to assess how they could contribute to the Queensland Roads and Tracks (QRT) network.
- **AT Demand Forecast Modelling Requirements:** To improve AT demand forecasting, the project explored the requirements for developing accurate models aligned with TMR's strategic plan. Discovery work was conducted to identify data custodians and demand forecast modelling techniques, which have been successfully deployed and can be used by policymakers to make decisions on future planning on AT infrastructure.

As the project progresses, ongoing efforts will focus on addressing gaps in current AT data methodologies. This work represents a step in supporting TMR's development of future forecasting models, enabling more accurate predictions and strategic planning for active transport demand across Queensland.



TOP: The extensive Bowen Hills Interchange in Windsor, Brisbane, Queensland, Australia (SS 2347158933).

GREENER ROADS, BRIGHTER FUTURE

Sustainability

The Sustainability stream includes projects dedicated to the NACOE program's commitment to sustainability improvements. The NACOE program invests in numerous projects to identify, research and share environmentally sustainable innovations and best practices for designing, constructing, maintaining and operating transport infrastructure.

SIGNIFICANT OUTCOMES OF THE NACOE SUSTAINABILITY STREAM INCLUDE:

- Environmental resilience and incorporating bushfire impact into road design
- Identification and testing of non-traditional and locally occurring materials
- Increasing the range of options for recycled materials in road construction
- Working with industry to facilitate the development of specifications that enable new and improved technologies
- Optimising the use of recycled materials in unbound and stabilised products
- Investigating the WHS and environmental impacts of recycled and novel materials
- Characterisation of bituminous products to enable increased use of recycled crumb rubber
- Assessing the potential greenhouse gas emissions reductions and sustainability benefits of innovative pavement solutions

O24 – YEAR 3

Recycled Materials in Stabilisation

GLOBAL INITIATIVES TO REDUCE RELIANCE ON NON-RENEWABLE RESOURCES HAVE GAINED MOMENTUM, SPURRED BY BOTH ECONOMIC CONSIDERATIONS AND ENVIRONMENTAL IMPERATIVES.

Stabilisation techniques, such as foamed bitumen stabilisation (FBS) and cement stabilisation, have been increasingly utilised in the construction of new pavements. However, the performance and mechanical properties of different recycled material blends stabilised using foamed bitumen and cement have not been well studied.

NACOE is currently in its third year of research into Recycled Materials in Stabilisation, building on the foundation laid in previous years. In Year 1 (2021–22), the organisation focused on three carefully selected recycled material blends, subjecting them to rigorous laboratory testing. The mechanical properties of foamed bitumen stabilised recycled blends and cement stabilised recycled materials were assessed, providing critical data on their structural integrity. Year 2 (2022–23) expanded the scope of the investigation, applying similar testing methodologies to five additional recycled material blends sourced from various suppliers.

This year, NACOE has been conducting field trials that demonstrate the benefits of construction using these stabilised recycled materials as a way to incentivise TMR districts and suppliers to use more of these materials in future TMR projects. A field trial was recently constructed on the Brisbane Valley Highway in Queensland to evaluate and monitor the performance of stabilised recycled materials within the pavement structure. Recycled crushed concrete with lightly bound in-situ stabilisation application was utilised in this trial. A range of laboratory and field-testing assessments were carried out both before and after compaction. Long-term performance monitoring will also be undertaken in the future.

In recognition of the outstanding quality and insights of O24, the project team received the 'AustStab Award of Excellence – Industry Excellence in Consulting, Research or Education' this year for their work: 'Using Recycled Materials in Stabilised Pavements'.

Future years of the project aim to explore additional field trials, with a focus on plant-mixed stabilisation methods.

TOP: Dr. Negin Zhalehjoo pictured with AustStab Award.
BELOW: AustStab awards of Excellence- Industry Excellence in Consulting, Research or Education- 2024 Winner NTRO, TMR & NACOE.

O25 – YEAR 4

Recycled Materials in Earthworks and Drainage

ALIGNING CLOSELY WITH AUSTRALIA'S 2018 NATIONAL WASTE POLICY AND THE 2019 NATIONAL WASTE POLICY ACTION PLAN, NACOE'S RESEARCH INTO THE USE OF RECYCLED MATERIALS IN EARTHWORKS AND DRAINAGE APPLICATIONS SUPPORTS THE TRANSITION TOWARDS A CIRCULAR ECONOMY IN INFRASTRUCTURE DEVELOPMENT.

Concluding the fourth year of the project, the work directly contributes to shifting the paradigm from 'take, make, use and dispose' to a more sustainable approach that maximises the value of resources. This year's research has centered on field trials and practical demonstrations, building on the comprehensive assessments of various recycled materials conducted in previous years.

NACOE completed an extensive review on recycled crushed brick (RCB) use in road applications, focusing on earthworks and drainage, which provides a foundation for future practical applications. In collaboration with UNSW Canberra, large-scale tests on reclaimed asphalt pavement (RAP) were conducted and analysed, gaining crucial data on its performance in earthworks. A comprehensive RAP field trial was also carried out, assessing its real-world performance.

Additionally, the design and construction of a field trial using recycled crushed concrete (RCC) as backfill material behind a retaining wall was completed. An ongoing detailed environmental monitoring on the discharge from the RCC is being conducted to address both engineering performance and environmental concerns. These efforts have significantly advanced understanding and practical application of recycled materials in transport infrastructure, particularly in earthworks and drainage applications where significant volumes of natural resources are required for construction.

These deliverables represent progress in understanding and practical application of recycled materials in transport infrastructure. The work continues to support TMR's commitment to sustainability and will be instrumental in refining guidelines and specifications for the use of recycled materials in earthworks and drainage applications.

TOP: Insulated pipe Large metal pipes with a plastic sheath at a construction site (SS 2156746143).

P117 – YEAR 5

Sustainability Assessment Tool for Pavements (SAT4P)

SAT4P HAS BEEN DEVELOPED AS A JOINT WARRIP-NACOE PROJECT FOR BOTH MAIN ROADS WESTERN AUSTRALIA (MAIN ROADS) AND TMR.

SAT4P is an online tool that enables the concurrent whole-of-life assessment of a pavement design's impacts and economic costs. The SAT4P compares every layer within the pavement from wearing course to subgrade. These detailed design comparisons allow users to determine which designs is optimal to the best cost benefits and lowest greenhouse gas emissions.

Now in its fifth year, the project is focused on developing robust, user-friendly software and its supporting databases. Built on extensive pavement engineering and sustainability expertise, the maturing project is delivering a publicly accessible online tool that will enable Main Roads, TMR and their industry partners to undertake sustainability and economic assessments of pavement options, leading to better-informed decision-making on material selections for projects. The tool has been subject to several phases of rigorous development and user testing, an independent peer review, and quality assurance processes to achieve a comprehensive, reliable, and fit-for-purpose assessment package. Further developer and user testing will be carried out upon the practical completion of key development stages.

In 2023–24, the SAT4P development process moved from addressing individual issues to developing themed works packages. Four major works packages were developed and implemented:

- Cost architecture – reassigning how pavement costs are calculated based on common pavement products.
- Developer – enhancing the user experience.
- Sustainability – automating several data selection options and calculations, including introducing national carbon values, to improve the user experience and assessment reliability.
- Database – reviewing and updating all reference and default data.

Additionally, an input-output works package is underway to enhance SAT4P reporting content, format, and functionality. This includes developing a report with assessment input data and calculation results, integrating assessment input data into the existing PDF report, incorporating case versus case comparison functionality into all reports, creating additional data visualisations, and implementing data security measures, including date and time stamping. The input–output works package is expected to be delivered in early 2024–25.

TOP: Sea Cliff Bridge Sydney Australia (SS 1947893380). **BELOW:** SAT4P diagram representing comparison of alternate cases and greenhouse gas emissions.

O28 – YEAR 2

Recycled Materials Supplier Database

TMR HAS BEEN SUPPORTING THE USE OF RECYCLED MATERIALS IN INFRASTRUCTURE PROJECTS, AND WITH THESE EFFORTS AND THOSE OF INDUSTRY INNOVATORS, THERE IS STILL AN OPPORTUNITY TO INCREASE THE USE OF THESE MATERIALS.

One of the main barriers is the lack of awareness about potential suppliers. Project O28 aims to develop a database and dashboard with information about state-wide suppliers of recycled material and products containing recycled materials. The dashboard will be accessible to internal and external stakeholders and will support the use of recycled materials in road projects across Queensland.

Stakeholders involved in the project include recycled materials suppliers and users, industry partners interested in the dashboard, other Queensland departments, local government authorities and contractors who will be completing Waste to Resource (W2R) Tender Schedules and sourcing and using recycled materials in infrastructure. The anticipated benefits of this project include increasing awareness of potential suppliers of recycled materials and driving local markets by encouraging the use of local material suppliers. The project aims to highlight the availability of recycled products and materials to support TMR's W2R Strategy.

The NACOE Recycled Material Supplier Dashboard will provide a free and easy-to-use platform to connect construction and infrastructure sectors with a network of recycled material suppliers, empowering informed choices and accelerating the shift towards a circular economy.

TOP: Drone photography of recycling center and machinery sorting materia (SS 2487107199). **BELOW:** Polymer for pipes plstic close up (SS 2202258317).

O36 – YEAR 1

Use of Limestone Cement in Stabilisation

CEMENT, THE HIGHEST EMITTING CONSTRUCTION MATERIAL[1], IS WIDELY USED IN PAVEMENT CONSTRUCTION ACROSS QUEENSLAND, PARTICULARLY IN STABILISED PAVEMENTS, AS WELL AS IN RIGID CONCRETE PAVEMENTS.

To address this challenge, NACOE has been making strides to improve cement technology by continuing its research into using cements containing increased limestone proportions compared to general purpose (GP) cements, for use in pavement stabilisation.

In general purpose limestone (GL) cements, limestone partially replaces clinker as a raw material in cement production with substantially higher embodied carbon emissions compared to limestone.

In Year 1, a comprehensive literature review and laboratory assessment of Type GL cements were completed to evaluate their potential as stabilising agents to compare them to GP cements. Now in Year 2, the research has been expanded into practical applications through field placement trials. Followed by a robust mix design in the laboratory, these trials will assess the performance of limestone cement in real-world conditions, contributing to a deeper understanding of its capabilities and long-term benefits in stabilised pavement projects.

This project not only supports sustainability initiatives by evaluating low-embodied carbon cement alternatives but also aligns with broader investigations into the use of limestone cements in concrete. By exploring and addressing potential barriers to market adoption, this project seeks to facilitate the wider use of Type GL cements in construction. In addition to environmental benefits, increased market potential for GL cements will lead to greater flexibility in the selection of stabilising agents for engineering purposes.

The outcomes of this initiative are expected to contribute significantly to both Queensland's infrastructure sustainability goals and broader industry efforts to reduce the carbon footprint of construction materials.

TOP: Close-up view of layered limestone quarry rock formations (SS 2399053443).

[1] Revolutionising concrete production with emission recycling, Australia's Economic Accelerator (2024). Available at: https://www.aea.gov.au/news/revolutionising-concrete-production-emission-recycling.

O38 – YEAR 1

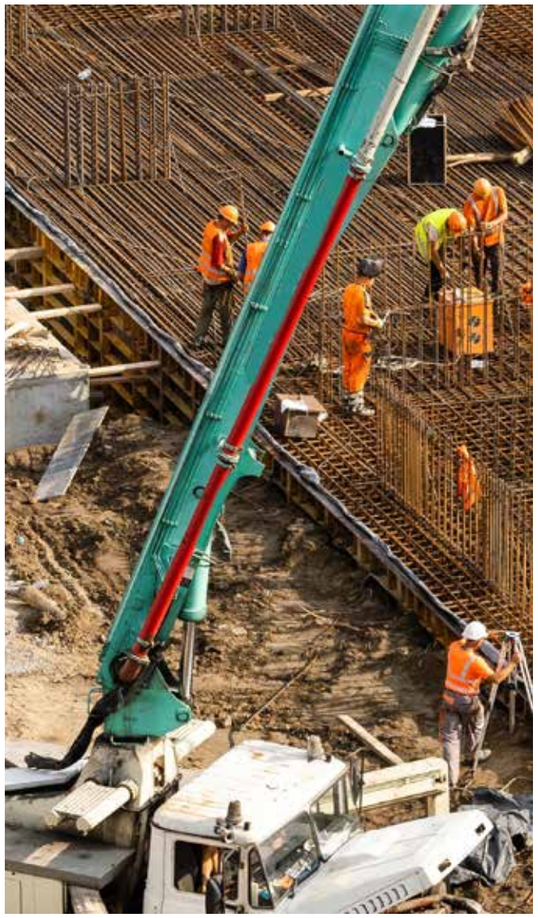
Decarbonised Construction

IN RESPONSE TO CLIMATE CHANGE, THE QUEENSLAND STATE GOVERNMENT HAS OUTLINED A NEW EMISSIONS REDUCTION TARGET OF 75% BELOW 2005 LEVELS BY 2035, AS WELL AS ENSHRINING IN LEGISLATION QUEENSLAND'S COMMITMENT TO NET ZERO EMISSIONS BY 2050.

In response, NACOE is taking action to bolster these targets and devise a strategy conducive to the decarbonisation of transport infrastructure. Mitigating carbon emissions currently constitutes a pivotal focal point for TMR in its research and development in infrastructure projects.

NACOE's O38 project supports increasing awareness and promotes dialogues relevant to decarbonisation in transport infrastructure construction projects. Identifying the potential for alternatives in materials, framework and procurement processes, anticipated benefits stemming from this process include:

- Refinement of existing carbon framework and approach
- Mitigation of carbon emissions on infrastructure
- Enhancement of TMR personnel's understanding of carbon emission sources and scope
- Increased understanding of whole-of-life for materials and life cycle assessment
- Consideration for both technical and non-technical solutions for decarbonisation



TOP: Construction site, concrete pouring (SS 2515753731).
BELOW: O38 Infographic Fact Sheets (Full version on next page).

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 at info@nacoe.com.au.

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

GET INVOLVED

THE NACOE PROGRAM RUNS ON A ROLLING FIVE-YEAR BASIS, WITH PROJECTS GENERALLY SPANNING ONE TO THREE YEARS.

The program relies heavily on input and collaboration between TMR, NTRO, 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. Suggestions for projects can be submitted through the NACOE website, www.nacoe.com.au or by sending an email to info@nacoe.com.au.

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