HIGHLIGHTS REPORT 2015-16

NACOE
NATIONAL ASSET CENTRE OF EXCELLENCE

AN INITIATIVE BY: Queensland Government arrb AUSTRALIAN ROAD RESEARCH BOARD

To contribute to lower-cost, quality infrastructure through knowledge and research

arrb
AUSTRALIAN ROAD RESEARCH BOARD

Queensland Government

Our Mission

NACOE will drive savings and enhance national technical capability in transport and roads asset engineering through:

- unlocking innovation
- implementing international best practice
- translating new knowledge into practice

Strategic Objectives

COST SAVINGS

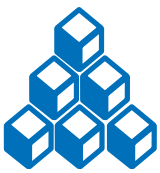
Delivering economic benefits to the Queensland network through cost-effective innovation and higher performing pavements, refined asset management practices, efficient management of structures and by optimising road safety and network operation outcomes

COLLABORATION

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

DEVELOPMENT

Developing the capabilities of staff and disseminating learnings to regions



IMPLEMENTATION

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

Foreword by NACOE Board

National Asset Centre of Excellence (NACOE)

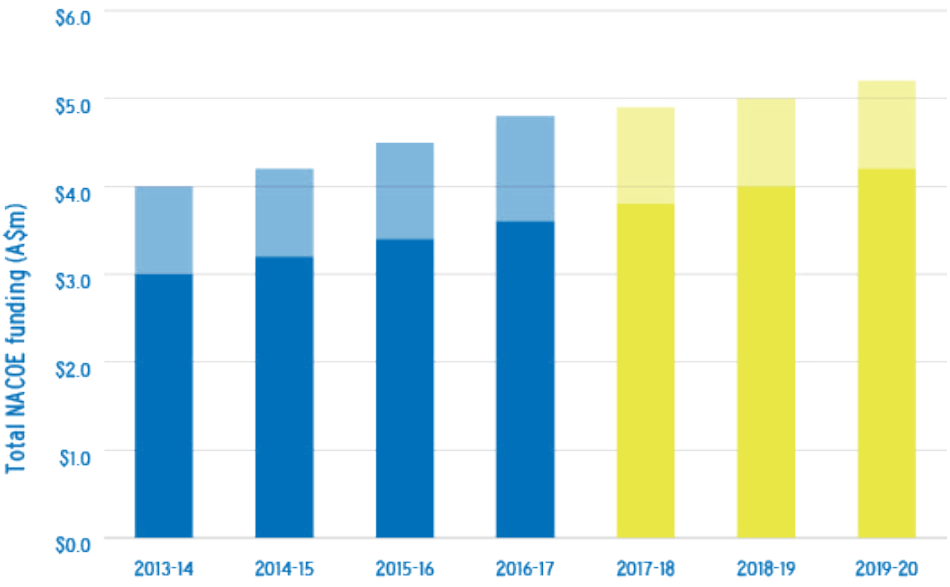
The NACOE is a commitment from the Queensland Department of Transport and Main Roads (the department) and the Australian Road Research Board (ARRB) to deliver:

- measurable financial and economic benefits
- increased technical capability across the transport and roads industry
- best practice engineering to Australia; and
- a research program that works in partnership with industry.

NACOE is a core deliverable under the Queensland Department of Transport and Main Roads /ARRB Agreement and achievements across the first three years of the program demonstrate that the department can, with confidence, achieve benefits far in excess of the costs. The program benefit / cost ratio to date is in excess of 20.

Under the Agreement, NACOE has a guaranteed five-year funding commitment (reaffirmed every 2 years), through a rolling four-year program, prioritised annually. The 2015-16 research program was funded at $3.4 million, as part of the $14.8 million rolling four-year program. This is a significant commitment from the department to invest in delivering significant savings through engineering excellence for Queensland and the national good. In addition to this base level of funding, industry is an active partner to NACOE investing $777,500 in 2015-16 and $957,500 in the first 3 years of the program.

The Agreement also provides for funding of an additional $1 million per annum, for the department staff to actively work within NACOE.



NACOE is committed to working collaboratively with other research centres to ensure there is no duplication and all learnings are shared nationally. Key partnerships with universities are also being established to ensure broad capability development is achieved through the delivery of this research. So far, NACOE has had research collaboration with Central Queensland University, University of the Sunshine Coast, Queensland University of Technology and the University of Queensland.

This report focuses on key highlights and findings from the 2015-16 NACOE program. It includes interim findings from a number of projects which are continuing into 2016-17.

The research program covers four key discipline areas:

- pavements
- asset management
- structures
- other, comprising:
  - network operations
  - road safety, and
  - heavy vehicle management

The department and ARRB are proud of the achievements to date under the Agreement and look forward to its expansion in partnership with industry to further unlock innovation opportunities in the transport and roads sector.

We would like to acknowledge the contribution of the retiring Managing Director (ARRB), Gerard Waldron and the retiring Independent Chair of the Board, Mr Neil Doyle who have both contributed significant leadership in the success of NACOE to date.

Gerard Waldron

Neil Doyle

The NACOE Board

Miles Vass

Julie Mitchell

Peter Damen

Garry Warren

NACOE
NATIONAL ASSET CENTRE OF EXCELLENCE

Benefits of NACOE

94%
Projects completed

>10
Agency Benefit/cost ratio

29
Publications developed
including Technical Notes and Specifications

18%
Funding from external partners

84%
Funding to priority research areas

NACOE is delivering strong economic benefits for Queensland, as a result of implementing outcomes from research projects. The first three years of the program have delivered many important project outcomes which have led to significant savings to the department, including:

- construction and material savings through reduced depth of thick asphalt pavements
- reduced conservatism with pavement and bridge design and maintenance
- potential crash savings through advocating effective road safety engineering treatments
- agency and road user cost savings through more efficient asset management practices.

Focussing on a select number of key projects within the program, it was found that the NACOE program has the potential to deliver agency cost savings of between $134 million and $292 million, against total program costs of $13.1 million. This will depend on full implementation, and this is now a key focus for the department. If fully implemented, the calculated benefit/cost ratio sits between 10 and 22, which is in the upper range of similar research programs internationally.

However, if we include broader road user and accident cost savings in addition to agency cost savings, the total benefits are estimated at between $278 million and $555 million, for an economic benefit/cost ratio of 31.4–64.7.

In order to facilitate this analysis in the future, a stronger emphasis has been placed on incorporating an estimated economic benefit assessment in the project proposal phase. The benefits of implemented research are difficult to quantify, once the initiatives become "business as usual", however they will be captured where possible to establish the benefits from the research investment.

The department is also now applying increased focus on implementation of research findings, to ensure that the full benefits are realised.

Note: All numbers are rounded.

Client Feedback

The 2015-16 client feedback survey found a strong level of support for the program within the group of the Queensland Department of Transport and Main Roads Project Managers.

Respondents believe there are benefits to be realised by the department and would support continuation of the program provided research is specifically targeted to the right areas.

Contributing factors to project success include managing projects locally out of the ARRB Brisbane office, and where project proposals are jointly development by both the department and ARRB.

In the future, the program would benefit from more frequent presentation of interim findings, and to ensure that project scope is very well defined before commencement.

>90%
Satisfied or very satisfied with overall management of projects

>90%
Satisfied or very satisfied with quality of final outputs

>90%
Believe the recommendations/findings can be implemented

>85%
Believe projects delivered value for money

>90%
Can identify potential savings to the department from projects

>90%
Believe projects will lead to increased knowledge or capability for the department

Future Direction

The early years of the program have focussed on achieving 'quick wins', by directing research funding to areas with strong prospects of direct cost savings for Queensland.

As the NACOE program matures and early research objectives are completed, the focus will change with more emphasis on:

- implementing research findings into practice
- seeking joint funding from external partners
- conducting more workshops and knowledge dissemination activities
- increasing capability building and development of research talent, through retention of expert personnel, further education, secondment opportunities and student internships

Co-location and accelerated pavement testing

Part of the NACOE initiative is to create the national pavements research centre of excellence in Brisbane. This facility will co-locate the department and ARRB in one complex with leading research material laboratories and equipment such as accelerated pavement testing devices.

This facility will be open to industry and universities, removing existing barriers to pavements innovation and promote capability development across the pavements industry.

The Queensland Department of Transport and Main Roads has relocated its Pavements and Geotechnical teams to Pinkenba, securing a new state of the art laboratory, and a modern office complex. ARRB is in negotiations for a relocation in 2017.

Awards and Achievements

Kath Johnston (left) and Clarissa Han (right).

Cost of Congestion of a Multi-modal Basis

This NACOE project measured the cost of congestion not only for cars, but for freight, buses, bicycles and pedestrians. The findings from two completed case studies were presented at the ITS World Congress in Melbourne in October 2016.

Lead authors Clarissa Han of ARRB and Kath Johnston of the Queensland Department of Transport and Main Roads, were selected as the winners of the Distinguished Scientific Papers - Asia Pacific award. Clarissa accepted the award on behalf of both authors at the Conference.

The findings were also presented and discussed at a specialist workshop at the ARRB Conference in November 2016 in Melbourne.

Peter Kadar

Incorporating uncertainty in Pavement Management System Modelling

This is an ongoing project that seeks to apply a probabilistic, quantitative risk-based approach to the modelling of pavement asset performance, allowing for an appropriate degree of uncertainty in the forecasting of network condition. The project team consists of Peter Kadar, Tim Martin and Ranita Sen of ARRB and Michelle Baran of the Queensland Department of Transport and Main Roads.

Peter Kadar presented a joint paper at the 9th International Conference on Managing Pavement Assets in Alexandria, Virginia (USA) in May 2015 based on elements of the research. The paper, titled Addressing Uncertainties of Performance Modelling with Stochastic Information Packages – Incorporating a Measure of Uncertainty in Performance and Budget Forecasts, won the Innovation Award at this international event.

Capability Development

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

- advancement of two PhD candidates from the department and ARRB
- mentoring of eight undergraduate pavements thesis, with Queensland University of Technology
- two secondments between ARRB and the Queensland Department of Transport and Main Roads, with further secondments proposed for 2016-17
- four pavements webinars disseminating new knowledge outcomes achieved through NACOE
- multiple papers and presentations at conferences across Australia and overseas including the Queensland Department of Transport and Main Roads, Engineering & Technology Forum 2014 & 2016, ARRB Conference 2014 & 2016, Austroads Bridge Conference 2014, International Conference on Managing Pavement Assets, ITS Summit 2016, AusStab Annual Conference.
- workshops through professional organisations and universities, such as the Australian Asphalt Pavement Association and the University of the Sunshine Coast
- 23 reports, presentations and papers available on the NACOE website
- 2 international journal publications

E&T Forum 2016

Pavements

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

- asphalt
- road surfacings
- unbound granular and marginal materials
- stabilised/modified pavements
- several sustainability and innovative technology projects (including alternatives to traditional pavement materials).

When implemented, findings from this research have the potential to deliver significant cost savings to Queensland and potentially other states, which will allow more road projects to be constructed.

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

- reduced depth of asphalt structural layers through:
  - adoption of EME (high modulus) pavement, and
  - refinement of thickness design based on improved temperature modelling
- improved understanding of the full implications of using non-standard and/or marginal granular materials through performance validation and evaluation guidelines. These pavements are widely used in western Queensland, due to non-availability of conforming materials. While they offer significant savings, they can involve increased risk of poor performance, so these risks need to be understood
- upgrading of many department specifications, based on the review of world's best practice, and laboratory research
- increased use of recycled and natural products in bituminous products across the network, to deliver environment benefits enhancing sustainability.

As the program evolves, the Agreement Managers are increasing emphasis on implementation. To achieve this, project teams will be increasingly involved in program development, and will remain involved in the project right through the implementation stage, to ensure success.

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

Cost effective design of asphalt at Queensland pavement temperatures

The Austroads design method for asphalt pavements is based on an assumption that increased thickness of asphalt will be required as temperature increases. This assumption has led to Queensland constructing very thick asphalt pavements, particularly on some of the heavily trafficked urban roads in the South East.

However, it has long been suspected that the assumption was not soundly based. NACOE, working with the University of Sunshine Coast and the department laboratory embarked on research to test the assumption.

After three years of research, the evidence was clear that a new method of pavement design (which did not automatically require increased thickness with increased temperatures was warranted.

Based on this research, the department is now releasing a new design approach which incorporates all of this research, and allows the thickness of asphalt pavements to be determined based on their properties. This change will deliver significant cost savings, as pavement designers can now capture the benefits of higher modulus, and increased fatigue resistant mixes, to reduce the depths of the asphalt pavements. This will allow the full benefits of EME2 pavements to be realised, as well as the benefits of the research into elevated temperatures.

The department constructs, on average, 150 lane-km of new full-depth asphalt pavements each year. This change will potentially save Queensland around $100,000 per lane-km or $15 million per year.

New design methods for the introduction of stiffer asphalts (EME2) can also avoid a complete layer of asphalt pavement. NACOE has worked with industry to prove this concept and will continue to work with industry in implementation of this new technology.

The department's approach to introducing new pavement technologies is to release a project specific specification, and work with industry and ARRB to refine the specification based on the outcomes of initial demonstration projects. Demonstration projects for EME2 are now being arranged, with a 10,000 tonne project on the Gateway Upgrade North (GUN) project.

- the Queensland Department of Transport and Main Roads is now releasing a new design approach which allows the depth of asphalt pavements to be determined based on their actual properties
- a departmental Technical Note will be released on improved design procedures for asphalt fatigue behaviour at elevated temperature
- upcoming trials of this alternative designs will occur on major freeways

New Technical Note to deliver thinner asphalt pavements to Queensland

- Research into cost-effective asphalt pavement design has led to the development of Technical Note 167 (TN167)
- The Technical Note implements findings from NACOE project outcomes that suggest that asphalt pavements in warm climates can be designed at a reduced thickness without compromising performance
- A typical heavy-duty asphalt pavement could see thickness reductions of 7% under interim recommendations
- Further reductions are likely through the adoption of high-modulus and innovative mix designs, including EME2
- TN167 would lead to indicative savings of around $850,000 per kilometre for a typical six-lane highway in south east Queensland
- TN167 has undergone review and is scheduled for release in early 2017
- This development was recently highlighted in the December/January 2017 edition of Roads & Civil Works Australia magazine

Pavements

- further research is needed to proof the extent of this concept, which could save millions per annum
- however, the department is implementing an early interim technical note outlining changes that can be made now to the current flexible pavement design method in Queensland
- the technical note has been through consultation and will be released in early 2017

Long life pavement alternatives for Queensland

NACOE research is carefully planned to complement research in other states, and other organisations, to avoid duplication. One area of research which illustrates this involves long life (perpetual) pavements. These pavements are deliberately designed to remain in service for many years, with the only requirement for periodic maintenance to the surfacing layer. This approach minimises the whole of life cost of pavements, by avoiding the requirement to remove and replace expensive structural asphalt. This approach also significantly reduces the impact on traffic operations during rehabilitation.

In 2011, AAPA initiated the Asphalt Pavement Solutions – for Life (APS-fL) project to develop an improved pavement design methodology. Based on the concept of fatigue endurance limit (FEL), the AAPA design methodology potentially results in substantial reduction in the design thickness of full-depth asphalt pavements. In February 2015, AAPA released the first draft of their AAPA design supplement to the Austroads pavement task force (PTF) for evaluation under an Austroads research project.

Austroads, NACOE and AAPA are working in partnership to explore the validity of this new design approach under Australian conditions. To date, it is clear that further research in this area is required.

Both the NACOE project and the Austroads project independently determined that limiting design traffic is the simplest and most compatible with the current AGPT:02 method. Limiting the asphalt thickness at 200 million standard axle repetitions was proposed as an interim approach for use on the departments projects.

- significant financial and performance benefits identified
- ability to incorporate treatment into perpetual pavement models
- TIPES Supplement for Thin Asphalt Surfacing Systems has been developed and released

Implementation of thin asphalt surfacing in Queensland

Queensland presently resurfaces many asphalt roads across the network with 40–50 mm overlays. An alternative approach is to use thin asphalt surfacings, which are comprised of a heavy tack coat or sprayed seal followed by a coarse gap-graded aggregate, with a typical thickness of 12–30 mm. Internationally these products have been shown to have performance benefits, material and cost savings, easier paving operation and ability to re-open roads more quickly after paving.

Thin asphalt surfacings can be used over previously sprayed seals, or to resurface existing asphalt pavements. They provide an economical solution for surfacing layers for EME2 pavements. There are a number of benefits in using thin asphalt surfacings, including reduced maintenance and rehabilitation expenditure, improved performance and better waterproofing. Many jurisdictions around the world base their road surface renewal programs around the use of thin asphalt treatments.

This project focussed on facilitating widespread implementation of thin asphalt surfacings across Queensland. As many propriety thin asphalt products are currently available around the

world, a process for approval for these products was required before they could be applied in Queensland.

A literature review of best-practice and of performance-related test parameters, in addition to a workshop with industry, have helped inform the development of a Transport Infrastructure Product Evaluation Scheme (TIPES) supplement for the assessment of thin asphalt surfacings. It is envisaged that trials of thin asphalt products can shortly begin in conjunction with TIPES applications to be applied nationally.

Products certified under TIPES will specify a range of environments, materials and traffic conditions under which the product would be suitable, allowing for accelerated procurement of thin asphalt treatments by road agencies across Queensland and Australia.

Maximising the use of rubber from end-of-life tyres in road construction in Queensland

End-of-life tyres are a potentially valuable resource for recycling. However, at present, most tyres in Queensland end up in landfill, are dumped, or are exported overseas. Rubber and carbon black represent approximately 70% of the weight of a tyre. One potentially high-value application for these materials is as crumb rubber modified (CRM) bitumen for use in road construction. The use of CRM binder in both asphalt and sprayed seals can lead to much improved field performance. CRM binder has been extensively used internationally.

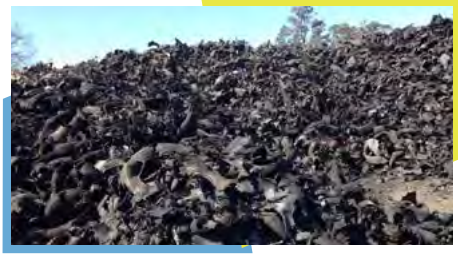
It has not been widely applied in Queensland, and has created problems when used in the past.

NACOE has negotiated a joint funding arrangement with Tyre Stewardship Australia (TSA), the Queensland Department of Environment and Heritage Protection (DEHP) and industry, with the goal of significantly increasing the use of CRM binders in asphalt and seals throughout Queensland – the right way.

The project has completed a literature review of applications, benefits and barriers to implementation, and conducted a demonstration project of a CRM binder sprayed seal in early 2015.

Recent work in 2015–16 included the development and modification of specifications for CRM sprayed seals and CRM open-graded asphalt. A project containing CRM binder in open-graded asphalt is planned for 2016-17. There are also future plans to develop specifications and conduct trials for gap-graded asphalt surfacing using CRM binder, and ultimately

- environmental benefits
- savings in reseal binder costs are estimated between $1–2 million per annum
- CRM binder in open-graded and gap-graded asphalt mixes are expected to deliver further significant savings.
- based on findings to date, this NACOE projects has:
  - updated MRTS18 (harmonised with Austroads) for CRM use in spray seals
  - developed a pilot specification for open graded asphalt with CRM



Case Study: CRM binder in South-West district resurfacing program

- during the 2015-16 financial year in the South-West District, a contractor submitted an alternative tender to use CRM binder instead of polymer modified binder across a large reseal program
- nearly 2 million litres of CRM binder were sprayed
- this recycled an equivalent of 59,000 passenger car tyres
- construction cost savings are estimated at $100,000, with 6% reduction in binder costs
- transportation cost savings, landfill/waste disposal savings and other environmental benefits totalled around $100,000
- life-cycle cost savings for the South-West District of $900,000 over the next 30 years are feasible
- this project demonstrates industry's ability to implement further CRM projects throughout Queensland

Pavements

conventional dense-graded asphalt.

While this project is expected to produce widespread environmental benefits through the recycling of waste tyres, there is also a potential saving in binder costs and evidence of improved performance with CRM products. At an estimated saving of 6–10% in binder costs alone, the department could be expected to save $1–2 million per year across sprayed seal works. Savings from utilising CRM binder in open-graded and gap-graded asphalt mixes are expected to deliver further benefits. The environmental benefits of recycling massive tyre stockpiles which could otherwise catch fire, or leach into waterways are also very attractive.

- Engineering and Technology Division of the Queensland Department of Transport and Main Roads stabilisation methods are national best practice
- research will progress to benchmark and consider international best practice, under Queensland conditions

Stabilisation practices in Queensland

The stabilisation of otherwise unsuitable road construction materials is an economically and environmentally beneficial alternative to replacement with conforming materials. However, there was evidence that the application of stabilisation technologies varies across the state and was influenced by historical local practice. As approximately 15% of the Queensland state-controlled road network incorporates stabilised structural pavement layers, there is scope for obtaining large savings if stabilising techniques can be improved and harmonised.

The objectives of the project are:

- to develop guidance on the best value-for-money stabilisation solution to adopt under various climatic, environmental and traffic conditions and
- to document standard practices for utilisation in Queensland.

NACOE has established that much of the stabilisation practice adopted by Engineering &Technology in the department is best practice nationally. In recognition of this, AustStab have recently initiated a project to harmonise foam bitumen stabilisation practices and specifications across Australia, based on current Queensland technology.

Based on research over many years, the department has progressively refined its stabilisation specifications, and achieved significant cost savings through reduced binder contents. Stage 1 of NACOE was to benchmark current practice. However, there may be further opportunity to achieve savings by examining overseas design methods. This will be reviewed in the future years of the program.

Evaluate and monitor high-standard granular base and seal

Heavily trafficked pavements in Queensland are traditionally designed and constructed using asphalt. However, it is known that unbound granular pavements are much less expensive to construct. Other Australian states have successfully applied unbound high-standard granular (HSG) base with a sprayed bituminous seal in heavily trafficked rural and moderately trafficked urban applications to realise these savings.

The use of HSG base in Queensland, was trialled as part of the Centenary Motorway upgrade project (complimentary to the TrackStar Alliance Springfield rail corridor development) and is currently being evaluated.

The use of unbound granular pavements for these traffic loadings can be risky, particularly if constructed in wet conditions. There have been previous instances of poor performance with these pavements in Queensland, predominantly thought to be due to lack of experience with this product. On this basis the project aimed to explore whether increased attention to quality assurance and construction techniques could reduce this risk to an acceptable level.

While the evaluation is still underway, early findings show the pavement is performing satisfactorily.

In making decisions on whether to make more widespread use of this pavement type, the department will need to consider a range of factors including:

- whether the high standard base required can be reliably produced by the gravel suppliers in the area, given the challenging geology in some Queensland quarries,
- whether the challenges in construction can be managed during variable climatic conditions, and
- whether skilled practitioners are available to ensure success.

If a shift can occur by utilising this material for these roads there is potential for significant savings per annum to the department using this alternative pavement practice.

- continued monitoring of the 2013 high strength granular base trial still shows promising results
- high strength granular bases are an alternative base layer to reduce costs
- experience in other states has shown that industry can develop capability to cater for this pavement type. Increased risk needs to be managed during the transition period

Development of a performance based evaluation protocol for non-standard granular pavement materials

Some 20,000 km of the state-controlled road network are composed of unbound granular pavement layers, generally sealed with a thin bituminous surfacing. Economic and environmental considerations encourage the use of locally-available and/or recycled aggregates for the provision of granular pavements. Particularly in more remote areas of Queensland, such as the Landsborough Highway in Western Queensland these materials often do not conform to standard specifications.

However, in normal seasons they can provide satisfactory performance when properly managed. Some of these materials were affected in the recent Queensland floods.

The objective of this project is to develop a standard laboratory evaluation protocol for determining the suitability of non-standard granular materials for specific pavement applications. The department has carried out substantial research into non-standard materials over many years, but much of this is information not generally available to practitioners. An exception is the Western Queensland Best Practice Guidelines which were developed in the late 1990's.

The assessment framework will be developed through:

- referencing these guidelines
- investigating national and international practices
- reviewing historical performance
- characterising Queensland materials using both conventional and
- advanced methods
- conducting field performance trials.

There is a desire to use more locally-available and recycled materials, to reduce costs and reduce environmental impacts, However, escalating traffic volumes and axle loads increase stresses on locally available materials (which are often lower strength) and

Pavements

can lead to earlier failures. Hence the use of these materials requires more reliable design methods to manage the increased performance risks.

The research is suggesting some changes to test methods. However, the variability of the materials provides a significant challenge with this research.

Several non-standard materials have been further characterised, including regional variations of sandstone and ironstone, and a range of natural and ridge gravels. The various test methods employed produced variable performance rankings, emphasising the need for further testing and analysis.

When completed, as a result of this work, the likelihood of early failures will be decreased, and road agencies can expect to realise significant cost savings due to reduced material haulage and a more efficient material selection procedure. Adopting these advanced processes will also encourage further innovation within the industry.

- improved understanding of the performance of unbound granular pavements
- use of non-standard and marginal materials can save in material costs while still providing satisfactory performance

Development of an advanced performance model for unbound granular pavements

Unbound granular layers with a thin bituminous surfacing are widespread across Queensland and are most commonly designed according to the Austroads methodology, with additional provisions for local conditions. However, unlike asphalt, concrete and stabilised (bound) materials, there are no specific performance criteria for unbound granular layers.

The design and management of these materials are based upon empirical relationships originally developed in the 1930's that do not consider the principal failure modes of rutting and shoving within the unbound granular layers. Historically, these empirical relationships contained sufficient conservatism to ensure adequate performance. However, greater traffic volumes, heavier axle loads and variability in material sources have increased the incidence of premature pavement failures and reduced the reliability of these empirical design methods.

The objective of this project is to develop a performance model for unbound granular materials to supplement the current Austroads design system. Development of a performance model is being pursued through:

- a review of international practice
- investigation of alternative technical approaches
- advanced characterisation of Queensland materials
- numerical modelling and
- field validation trials

Implementation within the department's pavement design system has potential to increase the selection of unbound granular versus more costly pavement materials, reduce the occurrence of premature failures and optimise maintenance strategy selection and scheduling.

This research is supporting capability development under NACOE and is the basis of a Ph.D.. To date preliminary findings have shown:

- approximately 25,000 km of the Queensland state-controlled road network is composed of unbound granular base layers and in 1996, 90% of these pavements were estimated to exceed design life. In 2015, the number fell to 60% as a

result of changes in materials, climate and loading conditions.
- 30% of premature failures are due to excessive plastic strain development requiring reconstruction of the pavement. This failure mode is not considered in the Austroads (2012) pavement design method.
- performance models considering both elastic and plastic deformation have been successfully implemented in the USA (mechanistic) and South Africa (empirical).
- based on the above, characterisation of representative Queensland materials and validation of the identified models are the focus of Year 2 of the project.

Queensland Department of Transport and Main Roads supplement to the Austroads sprayed seal design method

The current Austroads sprayed seal design method (AP-T68/06 and AP-T235/13) released in 2006 does not adequately reflect the current field observations and sealing practice in Queensland. The aim of this project was to capture and disseminate improvements to the seal design method based on learnings from its implementation in Queensland, through consultation with the department districts and the sprayed sealing industry. During the consultation process, the following key amendments were proposed:

- adjustments to the Basic Voids Factor for design traffic less than 100 veh/lane/day, due to an increased risk of bleeding/flushing occurring when using the current Austroads procedure
- adjustments to the aggregate spread rates for some single/single seals recommended by Austroads to better reflect current the department practices
- including an adjustment factor for very cubic aggregates, due to stripping issues previously observed with single/single seals using these aggregates
- adjustments to the Basic Voids Factor to allow for extreme loading conditions, i.e. where >65% EHV (which is not adequately covered in the current Austroads procedure)
- providing further guidance on appropriate embedment allowances for Queensland conditions to reduce the risk of excessive embedment occurring
- providing further guidance on appropriate PMB factors to use based on current the department practices
- providing further guidance on appropriate prime and initial sealing practices, based on departmental experience
- providing typical grades of cutback binders used in initial seals on departmental projects.

These amendments were documented in the Queensland Department of Transport and Main Roads Sprayed Seal Design Supplement scheduled for publication in the first half of 2017.

Benefits of traffic speed deflectometer (TSD) data in pavement analysis

The TSD is a truck fitted with Doppler lasers and a range of sensors that can measure the response of a pavement to loading at highway speeds. The deflection profiles can then be used to derive the bearing capacity and fatigue life of the pavement at small intervals. This allows for rapid data collection across the network, with between 10,000 km to 20,000 km of

Pavements

- TSD data is being used within the department's pavement asset management models
- correlations between the TSD and traditional analysis equipment are promising
- early analysis shows this data could be used in future for pavement analysis providing a potential cost saving in data collection to the department
- instrumented field trials planned to directly measure pavement response

the Queensland network now surveyed each year between April and June.

The TSD first commenced the Queensland data collection in 2014. The Year 2 survey was completed in August 2015, which included approximately 20,000 km of the Queensland road network. The TSD is currently used as a network assessment tool, which is reported at 100 metre spacing and is built into the pavement asset management performance models used across the department.

Based on the findings from Year 1 of this project, the deflection measurements from the TSD can also be used for pavement analysis to support pavement evaluation and rehabilitation designs. Preliminary work using common pavement analysis software such as CIRCLY and EFROMD3 is promising.

There are two parts in the Year 2 study:

- a correlation study to relate the Falling Weight Deflectometer (FWD) with the Traffic Speed Deflectometer (TSD), and
- an instrumented field trial to refine the method to measure pavement surface motion.

Pavement design for rehabilitation projects in Queensland is currently conducted based on deflection data captured by Falling Weight Deflectometers (FWDs). Collecting data using this equipment is slow and expensive, as the FWD must be established for each project, and it only provides data at a single point of time.

Network level TSD data will be immediately available to the pavement designer. Also, after it has been collected for several years, pavement performance during particular climatic conditions can be evaluated. This provides an efficiency to the current design practice.

As this research is progressed it will be shared nationally.

- The TNRP flood recovery program included $3.5 billion worth of pavement works, covering 4,900 km
- this project has identified key areas for future improvement in pavement design guidelines and practices. Even a small improvement in efficiency of 5%, can potentially save $175 million in a future flood recovery program

Evaluating the performance of Transport Network Rehabilitation Program (TNRP) flood repair works

Between 2010 and 2013, Queensland experienced widespread flooding over most of its road network. Repairs to the resulting damage, constructed under the Transport Network Reconstruction Program (TNRP), cost $6.4 billion.

This three-year research project aims to identify best practices and lessons learnt from the TNRP, particularly in pavements and pavement repair techniques.

The findings from this project will be used for the improvement of the design guideline for future flood recovery works. Given the scale of the area affected, considerable variations of pavement works undertaken and the construction practices adopted in each region, the TNRP provides the department an excellent opportunity to identify optimal reconstruction practices. Of the $6.4 billion TNRP program TNRP pavement related repairs to approximately 4,900 km of road had an estimated cost of $3.5 billion. Even a small (5%) improvement in practices would translate to $175 million in savings for the department in a similar future program.

Also, by constructing improved pavements through applying NACoE research a further saving in ongoing maintenance costs can be achieved. With projected maintenance

expenditure in excess of $2 billion over the next ten years, a saving (or achievement of better value) of 10% in maintenance expenditure through improved pavement performance could potentially deliver savings (or increased maintenance value) of $20 million per year.

This project is continuing, but already there are indications that increased application of the Modified C grading (based on earlier NACOE research) and improved stabilisation practice can deliver substantial savings for future programs.

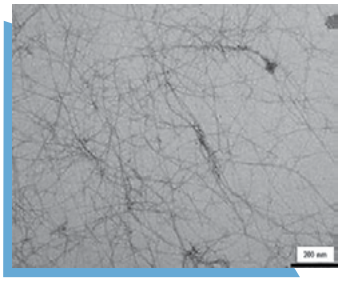
Australian native arid grass for enhancing the performance properties of bituminous and concrete material

The department is contributing $60,000 over 3 years towards an Advance Queensland funded program to investigate the possible application of nano-fibre derived from spinifex grass to bitumen, for use in asphalt and in concrete.

The research being led by the University of Queensland, with guidance from NACOE, will need to establish whether the nano-fibres materially affect the properties of the bitumen and concrete, and if so, whether this is economical compared to other additives currently used in bitumen, asphalt and concrete.

This is 'cutting edge' research, as the potential for these nano-fibres (which are unique to arid Australia) has not been explored elsewhere. If the research is successful, collection of the spinifiex and extraction of the nano fibres in commercial quantities will be investigated.

Spinefex grass



Spinefex nano fibres

Asset Management

The NACOE Asset Management Program has focused on advancing asset management modelling practice and the underlying assumptions within these models.

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

It is expected that the program will deliver benefits to the department in terms of:

- more robust and accurate asset management tools and models, which will enable the department to better prioritise maintenance and rehabilitation spending, through informed decision making
- 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 and optimisation of private-sector road asset management contracts

- seven case studies have found that better targeting of maintenance and rehabilitation could improve network resilience
- optimised 'best-for-network' would return an estimated marginal benefit-cost ratio of 3.7
- the stitch-in-time model the analysis calculated a cumulative life-cycle cost saving of $596 million for a marginal benefit-cost ratio of 6.9.
- the department have accelerated $100 million of programmed maintenance, rehabilitation and drainage maintenance in 2016-17, based on learnings found in this study

Accounting for life-cycle costing implications and network performance risks of rain and flood events

Between 2010 and 2013, the Queensland road network was impacted by a series of major cyclone and rainfall events that caused $6.5 billion dollars of damage to the network. The Transport Network Reconstruction Program (TNRP) was established to facilitate the state-wide recovery of the state-controlled road network.

This project seeks to quantify the impact of these events in a life-cycle costing framework, and to identify the funding levels required to improve the resilience of the network as it responds to future rain and flood events. A series of case studies was developed that enabled a comparison of three investment scenarios; the base case of what actually happened, a full resilience scenario and a 'stitch-in-time' approach to road rehabilitation.

A life-cycle costing model was developed to facilitate this analysis. The study found that large benefits can be realised through the full-resilience option, but that this requires a very high agency investment. In contrast, the stitch-in-time approach may not require increased total agency costs, and still deliver reduced road user costs, and reduced flood damage risk.

While the cumulative economic effect of the full-resilience model was negligible over 30 years across the case studies, for the stitch-in-time model the analysis calculated a cumulative life-cycle cost saving of $596 million for a marginal benefit-cost ratio of 6.9.

A best-for-network strategy was also proposed, where the best option is chosen for each link, leading to an overall marginal benefit-cost ratio of 3.7. The anticipated life-cycle benefit of the best-for-network strategy could extend to $16 billion over the 30-year analysis period.

In addition, it was found that the enhanced drainage maintenance across the state-controlled network, will reduce the extent of damage. Based on this finding $100 million of programmed maintenance, rehabilitation and drainage maintenance has been accelerated in 2016-17.

Improved model to predict the remaining life of sprayed seal surface

The majority of the Queensland state-controlled road network has a bituminous sprayed seal surface. A national bitumen survey previously undertaken has identified a significant variation in the long term durability of bitumen used in sprayed seals throughout Australia.

At least 30% of bitumen samples tested over a five-year period did not meet typical minimum durability requirements, increasing the risk of reduced seal lives. Research suggests high economic costs associated with sprayed seals with low bitumen durability, with a doubling of annualised costs over the bitumen life-cycle compared with a compliant bitumen.

To date, this project has focused on identifying a non-destructive technology for identifying aged binders in-situ and the benefits associated with achieving more durable sprayed seals. The project drew on field data for actual seal ages and associated condition states. The study findings have quantified the potential benefits of timely resealing, and the benefits of supplying binders with a higher durability.

It was also found that there is currently no viable method available, both locally and internationally, for identifying aged binders in situ. Asset managers currently use a bitumen durability test (AS 2341.13) to estimate the remaining life of sprayed seals. This test was found to be time consuming and cannot be applied to modified binders, which are increasingly used throughout Queensland. A need was therefore identified to develop an improved model to predict the remaining life of sprayed seals.

As part of this, the Dynamic Shear Rheometer (DSR), recently purchased by the department, was identified as a testing device that could potentially be used to predict the remaining life of sprayed seals. The next phase of this project will focus on developing a methodology that uses the DSR to estimate the remaining life of sprayed seals

- variance in durability levels appears to be a major factor in premature failures
- timely resealing and more stringent durability testing will help to reduce the risk of early failure
- DSR will be trialled to meet this test need.

Impact on pavement surface condition of substantially reduced maintenance

The department needs to be able to quantify the impact of low maintenance strategies on the condition of its road network. Traditionally delays in optimal reseal timing (by up to 30%) and deferred pavement rehabilitation can occur as a result of competing budget priorities.

This project examines the evidence of the low maintenance strategy on the road network in three South-East Queensland regions to calibrate deterioration models.

Asset Management

- new pavement deteriorations models will be implemented in 2016-17, taking into account the performance of the state-controlled network under low maintenance funding strategies

Further research is required to refine the models accuracy in areas such as crack initiation prediction for the effect of varying maintenance.

It is suggested that the results from the NACOE "Improved model to predict the remaining life of sprayed seal surface" project be used to inform crack initiation times based on Queensland binders. Results from this study can also be used to describe a distribution of oxidation lives, and therefore crack initiation is kept separate to other factors such as reflection cracking.

In 2016-17 the deterioration models (Austroads) will be adjusted to also reflect data not available in the department asset database, such as the impacts of Thornthwaite Moisture Index (TMI) and the derivation of the modified structural number from TSD survey data.

Incorporation of the pavement risk score into the pavement condition index

- reviewed elements incorporated into dTIMS
- technical outcomes will be incorporated in Department new PMS and applied state-wide in strategic planning
- further review and validation has commenced

The department developed a Pavement Risk Score (PRS) to reflect the risk to pavement preservation/failure and safety. The PRS relies on measured condition data and information on the operating environment. Since the initial development of the PRS, a Pavement Management System (PMS) was introduced together with the Pavement Condition Index (PCI). The PRS was also implemented in the PMS as a trial with only limited calibration and review but was not integrated in the PCI.

The main objective of the project is to review, calibrate and incorporate the Pavement Risk Score developed by the department into the Pavement Condition Index implemented in the department's pavement management system. The condition indexes (CI) and their aggregated form (PCI) is used to measure performance, trigger treatments and it is a key component of the work optimisation process.

Consequently, their formulation is critical for the optimum utilisation of available resources and for the determination of resource requirements.

The correct settings of the relevant condition indexes will also assist in establishing realistic performance targets.

Experience shows that early automation and streamlining of calculations brings substantial benefits in terms of efficiency and reliability of the asset planning / modelling work. This improved understanding will allow for consistent assessment of the risks to the department and road users from current and future budgetary allocations.

Several reviewed elements were implemented in the department dTIMS model in January 2016. This implementation will reduce the quantity and complexity of the code and reduce run time when sensitivity analyses are run to compare field validation of the PCI and PRS indices.

Structures

The Structures Program comprises six projects representing around 20% of the NACOE program investment in 2015-16.

The structures program will seek to deliver benefits to the network in a number of ways, including:

- 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
- development of staff capacity in the use of advanced assessment technologies and instrumentation of structures
- improving bridge monitoring and management through the use of advanced systems and by adopting world's best practice in asset and risk management
- introduction of advanced materials and technologies into structures across the network.

Measurement of bridge-vehicle interaction under live load

The department is responsible for over 3000 bridges and 4000 major culverts. The gross replacement value of these structures exceeds $11 billion.

Throughout Queensland, the cost to upgrade or maintain bridges is currently subject to load restrictions, in the order of $120 million.

Significant national and international research has been conducted in the last few decades on dynamic bridge-vehicle interactions and the amplification of dynamic wheel loads on pavements and bridges, particularly in relation to the assessment of existing structures.

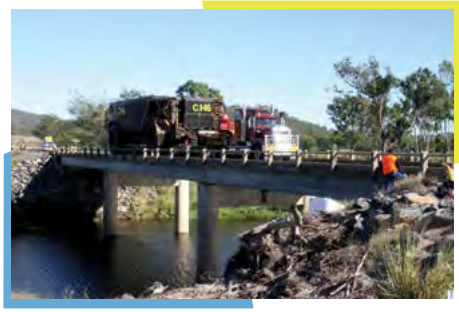
With the evolution of 'road-friendly' suspension-type vehicles, improved vehicle design/technology, and the move towards the introduction of performance-based standards (PBS) for heavy vehicles, the department is seeking to explore this area further to investigate and to explore opportunities to improve network efficiencies and economic benefits.

- instrumented bridge load testing undertaken with various heavy vehicles
- findings indicate vehicle and suspension type influence response
- frequency domain critical in understanding dynamic reactions and is bridge specific.

Of particular interest is the use of the Dynamic Load Allowance factor, a constant specified in the Australian Bridge Design Code. The department is investigating whether this factor can be adjusted based on the actual structure, vehicle loadings, road profile and bridge condition. This could lead to reductions in unnecessary maintenance and access restrictions, and an increase in freight movements, translating to economic and efficiency benefits. This research is unique and there has been little published or documented in this area.

The department and ARRB embarked on an extensive bridge load test program for three representative

- instrumented bridge load testing undertaken with various heavy vehicles
- findings indicate vehicle and suspension type influence response
- frequency domain critical in understanding dynamic reactions and is bridge specific



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Structures

- deck unit bridges showing better performance than predicted by existing models
- models and guidelines updated to incorporate new analysis
- potential savings in bridge strengthening demand in excess of $10 million

prestressed concrete bridges of varying structural type. Various test vehicles were employed (semi-trailers, road trains, 4-axle crane) and the response of the bridge to each of these vehicles at various speeds and direction of travel was recorded and analysed. The amplification of load experienced by each test bridge was assessed against the vehicle suspension type and the road profile condition.

Findings indicate that the vehicle and suspension type influence the overall dynamic response of the bridge, as does the condition of the road approaches to the bridge. Interpretation of individual bridge and vehicle responses in the frequency domain has also proven to be critical in understanding their dynamic interactions.

The variability of performance, indicates that network level adjustments to the dynamic load factor cannot occur. To adjust this factor individual bridge loading to understand the frequency domain is required.

Deck unit bridge deck analysis under live load

The department currently manages approximately 3000 bridges, of which more than 1300 are transversely stressed deck unit bridges. Several of these structures were designed in the 1960-70s period, featuring low depth and limited shear reinforcement, and are unique in design and performance. A number of these structures are currently subjected to access restrictions based on previous theoretical assessments. While these assessments indicate overloading, the observed actual in-service performance does not necessarily indicate distress. Accurate modelling of this family of bridges has been difficult to achieve.

Developing consistent guidelines for analysis is needed to ensure that rating and assessment results are accurate. Grillage models (modelling of individual elements of a structure, and combining to apportion load transfer appropriately), require calibration against actual responses of in-service and bridges. Ultimate strength/capacity of deck units also needs to be determined and/or confirmed through load testing. Investment in this research is critical to enable the department to maximise access to the state freight network in order to improve economic productivity. A better understanding of performance will also enable the department to address the current list of priority bridges for rehabilitation, strengthening or replacement, potentially saving many millions of dollars.

The primary purpose of the project is to gain a better understanding of the assessment and performance of transversely stressed deck unit bridges. The project also includes:

- development of practical methodologies and procedures for instrumenting and load testing
- calibration of computer models with actual performance
- verification of individual deck unit structural performance (ultimate strength) through controlled laboratory testing
- provision of input to the departmental guidelines with respect to structural capacity assessment to deliver improved understanding of transverse distribution of live loads

Early learnings from the first two years of the project support the hypothesis that these bridges behave similar to solid concrete bridge decks and perform

better than current assessments reflecting their condition and performance in the field. Analysis of the data indicates lower than expected dynamic load allowances for certain vehicle types. Results from in-service load testing of Canal Creek Bridge have been used in re-evaluating the current access restrictions on the bridge.

Laboratory testing indicates that the individual deck and kerb units have higher ultimate capacities in both shear and bending than predicted. While further testing is planed through to 2017, inputs are being considered in the department Priority Bridge Program, which combined with other inputs should see reductions in load restrictions applied across the state.

Asset management system review

The department is responsible for the management of 3,000 bridges and 4,000 major culverts. Effective and efficient risk-based structure management requires a suitable fit-for-purpose asset management framework, reliable access to current and relevant data on our highway structures and reliable tools to assist with the quantification and prioritisation of risk both at the structure and network levels.

The department's Bridge Inspection Manual (BIM) embodies the department's asset management framework for bridges and major culverts, establishing a state-wide policy and documented accountabilities along with procedures for systematic inspection and reporting along with data management requirements.

This manual successfully in place for 10 years required udating to encompass all bridges, significant highway structures such as tunnels, metal culverts, structures supporting large signage and new materials. The purpose of this project is to evaluate the existing the department Bridge Management System against current and future needs.

Specifically, the project involved a review of best national practice and inputs from past ARRB international reviews. The existing inspection manual has also been amended to address all structure types, including bridges, culverts, tunnels, retaining structures, scour/coastal protection and VMS gantry structures. It also covers the management of the Story Bridge, the Riverside Expressway and other unique/significant complex structures. Risk management will be investigated into as well as the development of an integrated asset management system.

The following tasks were successfully completed in Year 1:

- development and release of an interim revision to BIM (Bridge Information Management System) Part 1 (Policy) outlining procedures for management of asbestos containing materials
- updated revised scope of physical assets
- recommendations for changes to the current BIM Technical Advice Notes for incorporation into BIM.

These findings will be implemented by publication of the Structures Inspection Manual, which includes the implementation of an online feedback process and new business procedures to ensure feedback is managed in a transparent and timely fashion. The final project report will include an improvement plan to address any gaps/non-conformance identified through the ISO 55000 benchmarking exercise.

Structures

Determination and development of optimum distribution of servicing and routine maintenance funding to achieve best value-for-money

The department presently allocates approximately $15.8 million/year for the servicing of structures on the road network. The requirements of the works are set out in the department's Bridge and Culvert Servicing Manual. Over the four years since the commencement of the servicing program, it has become apparent that either increases funding or improved use of exisiting funding is required to meet the maintenance need.

In order to obtain the best value from available expenditure, the department needs greater knowledge of the servicing needs of the various structures around the state. It is suggested that such knowledge could be developed through a detailed review of the existing servicing regime, considering and quantifying the costs and benefits of the present program.

The key benefit of the research will be to ensure that current servicing and routine maintenance activities align with the goals of the asset management plans and are optimised to offer best dollar for performance outcomes.

Accordingly, the benefits will be:

- increased cost effectiveness of available expenditure
- expenditure is optimised to meet desired level of service goals including network availability and reduction in unplanned maintenance
- improved understanding of current expenditure.

This project will be completed in 2016-17.

Other

A further four projects are funded under NACOE in the fields of Network Operations, Road Safety and Heavy Vehicle Management, totalling roughly 15% of the total program investment.

Current departmental initiatives include:

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

Through NACOE, a number of projects will also be looking to advocate the use of smarter technology and sustainable solutions on Queensland roads.

Evaluation of in-service road-friendly suspension compliance using on-board vehicle technologies (RFS)

Heavy vehicles fitted with road-friendly suspensions (RFS) are permitted to operate on select routes at higher mass limits. This productivity benefit is permitted on the assumption that a RFS reduces pavement damage. Vehicle Standard Bulletin 11 (VSB-11) defines the test method for certifying a new suspension as a RFS. Despite evidence that the performance of a suspension does degrade over time, there is no quantitative test method to determine in-service compliance requirement for RFS. The review included consideration of advancements in telematics, accreditation, software models and technologies and suggested possibilities of new ways for in-service testing of RFS.

The preliminary findings indicate that in the past the major obstacles to an in-service test for RFS have been:

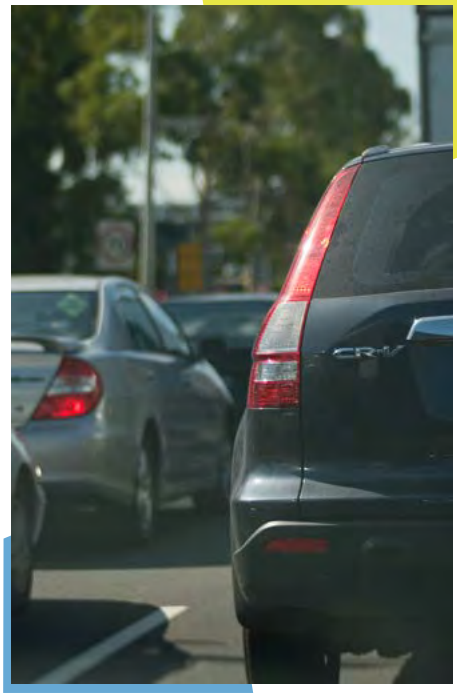
- identifying a cost effective approach that doesn't involve removal of components or major interruption to vehicle operation.
- knowledge gaps and disagreement on the link between performance characteristics of a suspension, road friendliness and the amount of pavement wear

An evaluation was undertaken by performing a field testing of selected RFS measurement technologies. The results of the tests have been summarised including limitations that would need to be considered prior to an operational evaluation in the final stage of the project.

At this proof of concept stage of the project, some in-service testing methods have proven suitable to explore further in 2016-17. At this point however, the lack of a suitable excitation method is a limitation that prevents an on-board technology being used to its full potential as an in-service test method.

- suitable methods have been identified for in-service testing of RFS
- planned to evaluate potential options through a pilot study in 2016-17

- identified congestion costs for public transport and ramp-metering case studies
- when normalising by VKT, more significant cost savings was identified, especially during the morning peak when ramp metering was active.
- reductions of total congestion, excessive delay and reliability costs per 1,000 VKT were 30%, 42% and 12% individually during morning peak



Measuring the cost of congestion on a multi-modal basis (on-road)

The first year (2014-15) produced a methodology paper for estimating congestion costs associated with on-road buses and freight and it also performed a feasibility study estimating congestion costs for bicycles and pedestrians. The second year (2015-16) applied the multi-modal cost of congestion methodology to undertake two case studies.

Case study 1 looked at bus congestion cost evaluation on Gympie Road using Translink Go Card data. The bus data analysis yielded reasonable congestion cost values that closely followed expected commuting patterns. Average total congestion cost per weekday for Gympie Road buses was found to be approximately $45,000 while the daily cost was approximately $15,000 for weekends. Additionally, analysis of daily variation in congestion cost showed this consistent pattern of low congestion cost for weekends and high congestion cost for weekdays explicitly. It is noted that passenger waiting times are a significant proportion of the total congestion delay cost of buses.

The profile of congestion costs within a typical weekday displayed two distinct peaks between 7-9 am and 3-6 pm, corresponding with the morning and afternoon peak commuting times. In contrast, during a typical weekend day the congestion costs profile showed much less distinguished peaks with possible maximums at mid-morning, mid-afternoon and late-evening.

The second case study involved a before and after evaluation of a major urban road project (Bruce Highway ramp metering) to determine their congestion reduction impacts. The case study revealed that although the average daily Vehicle Kilometres Travelled increases by 5%, the cost of congestion after the installation of ramp metering was reduced. The average cost of congestion on a weekday in 2015 was approximately $100,000, while in 2016 after ramp metering, it was approximately $80,000, representing a cost saving of approximately 20%. For a typical weekday, the congestion cost reduction mainly comes from the morning peak when ramp metering is operating.

This research was presented at the ITS World Congress in Melbourne in October 2016, where it was selected as the winner of the Distinguished Scientific Papers - Asia Pacific award. The findings were also presented and discussed at a special workshop at the ARRB Conference in November 2016 in Melbourne.

Monitoring and Evaluation of Safety Treatment Performance on the Bruce Highway

The Queensland Government developed the Bruce Highway Action Plan to improve the operation and safety performance on the Bruce Highway. The safety component of the plan uses the latest innovative engineering solutions, such as wide centreline treatments and wire rope safety barriers to maximise the return on investment.

Since these treatments are relatively new in Queensland, an on-going monitoring and evaluation is essential to ensure the expected benefits are realised and that knowledge of their performance is improved and applied to future decisions

and implementation of the Action Plan and more widely within the department.

The purpose of the project is to evaluate the effectiveness of road safety engineering treatments on the Bruce Highway, including reduction in fatal and serious injury crashes and financial savings. This includes evaluation of the impact of the wide centreline treatments on travel speeds (mean speed and 85th percentile speeds).

The updated analysis indicates that installation of wide centrelines on the Bruce Highway can be expected to reduce overall fatal and serious injury crashes (FSI) by approximately 22% and reduce cross centreline FSI crashes (including head-on crashes) by approximately 43%. Due to limited data at some sites, an updated analysis will be required as data from more treatment sites becomes available in order to confirm these findings.

The department is implementing the findings of this work for the broader benefits of the road user.

Network wide review and analysis of intersection crashes on Queensland roads

A review of existing historical crash data has identified intersection crashes, run-off road crashes and head-on crashes as the three key crash types to occur on Queensland roads. These crash types account for most of the serious injury crashes (fatal and hospitalised) on the entire Queensland network.

The 2015-16 project involves review and analysis of intersection crashes to enable key drivers behind intersection crashes to be understood, and the numerous variables attributed to these crashes to be identified. This understanding will enable more specific and focused strategies to be adapted for improved safety outcomes for these high-risk crash types. This will lead to improve economic returns on investments from existing programs such as "Safer Roads Sooner".

A literature review and crash analysis across Queensland was undertaken, with the study finding that:

- intersection crashes account for 44% of all injury crashes, and 37% of fatal and serious injury (FSI) crashes, despite intersections and their approaches comprising only 5% of the network
- intersection injury crashes occurred at T-junctions (47%), cross-intersections (34%) and roundabouts (10%)
- 60% of intersection injury crashes occurred at intersections with no traffic control or controlled by give way sign only, a further 31% occurred at signalised intersections
- the most common intersection injury crashes have been angle crashes (57%), rear-end (21%), hit object (10%) and pedestrian crashes (4%), with a focus on treatments that address these crash types being necessary.

NACOE Website

The NACOE website provides access to key reports and the latest developments across the NACOE program.

A key focus of the website is the dissemination of learnings from the program, so that the potential benefits of each project can be captured by a wide audience.

At the end of 2016, a total of 23 research project reports, webinars and presentations are available for download through the website.

Website: nacoe.com.au

Get involved

How to get involved

The NACOE program runs on a rolling four-year basis, with projects generally spanning 1 to 3 years.

The program relies on the input and collaboration of ARRB, the Queensland Department of Transport and Main Roads and industry personnel to develop ideas for projects across the four key discipline areas of pavements, asset management, structures and other (network operations, road safety and heavy vehicle management).

Any suggestions for projects can be submitted through the NACOE website, at nacoe.com.au or through the NACOE email address info@nacoe.com.au

Feedback and contact details

The NACOE Agreement Managers can be contacted with any feedback or to make enquiries regarding the program or specific projects.

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