Austroads
promoting improved road transport outcomes

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Austroads-ARRB Partnership Agreement

Programs and achievements 2010-11





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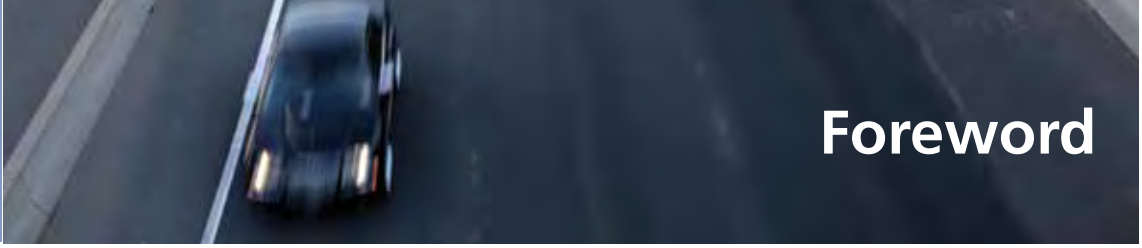

Foreword

Gerard Waldron
Managing Director
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This is the first annual report on ARRB research activities carried out under the Austroads – ARRB Partnership Agreement covering 2010/11. This new agreement follows the highly successful Technical Research Agreement which commenced in 2004/05.

Over the six years of the Technical Research Agreement, ARRB rebuilt and consolidated research expertise in the core areas of asset management, bituminous surfacings, pavement technology and road safety engineering. In doing so a significant body of research work has been delivered in support of the objectives of the current *Austroads Strategic Plan 2007–2012*. There were 57 projects under the 2010/11 Partnership Agreement with total budget value of $6.37 million.

ARRB's vision is to be a trusted advisor to road authorities for technical input and solutions. In the annual survey of key stakeholders undertaken by Austroads, 78%of Board members were satisfied with the quality and relevance of the Austroads technical research undertaken by ARRB, and over 65% of Board members stated that the Austroads technical research undertaken by ARRB had provided significant benefits to their organisations.

A key mechanism for facilitating research into practice is the publication of Technical and Research reports and the Austroads Guides, which now comprise 96 separate parts with the addition in 2010/11 of the *Guide to Road Tunnels*.

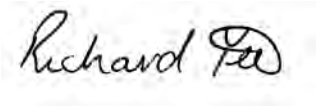
ARRB delivers an active knowledge transfer program to support implementation of the research findings with between 50 and 80 separate events each year, together with the biennial ARRB conference which attracted over 600 delegates in 2010. ARRB has pursued registered training organisation status, which now enables ARRB accreditation of selected courses in association with the University of Ballarat.

We welcome the broadening of the core technical areas to include Network Operations under the new Austroads – ARRB Partnership Agreement. This discipline is a key to improved travel time reliability and the huge benefits of developments in cooperative intelligent transport systems linking vehicles and infrastructure.

ARRB celebrated its 50th anniversary in 2010 and in line with the unanimous member support for ARRB as the Australasian road research centre, expressed in December 2010, ARRB is refocusing on member needs and further building sustainable expertise in the five core technical areas.

Building on a strong base, the Austroads – ARRB Partnership Agreement has already produced significant outputs as reflected in this report for 2010/11. Further enhancement of this agreement is in progress for 2011/12 and beyond to ensure that ARRB research continues to underpin technology development and innovation for the next *Austroads Strategic Plan 2012–2016*.

Gerard Waldron



Richard Yeo

The challenge to industry and the Austroads response

The challenge to industry

In late 2003 and early 2004, Austroads members became increasingly aware of declining levels of technical expertise in a number of areas which are central to their ability to achieve their objectives. In looking to ARRB to fill the 'expertise void', a number of key points became apparent:

- ARRB was established in 1960 by the Australian road authorities as a research cooperative using funds that the jurisdictions received under the *Commonwealth Aid to Roads (CAR) Act*.
- ARRB's research budget dropped in real terms from around $8 million in 1992 to around $2 million in 2003/04, representing only 15% of total revenue. The funding, and hence scope, of the projects within the program also dropped significantly.
- The reduction in ARRB's core research business resulted in a loss of experts and further losses were anticipated in the immediate future based on the age profile of staff. ARRB exists to provide expertise to Austroads members. This expertise resides in the knowledge of its staff, which is based on the research they have conducted in the past. This expertise is available and is being accessed now, but must be continually renewed as staff age and retire or their expertise loses currency. If ARRB does not do research, it cannot sustain its expertise for the benefit of members.
- ARRB should also be in a position to respond to new and emerging issues which may not have formed the basis of its research effort in the past.

In May 2003 the Austroads Council approved the establishment of a Technical Research Program with a commitment of core research funding to ARRB. Significantly, the primary objective was to rebuild expertise and experience within ARRB which would then be available to Austroads members to assist in responding to current and emerging issues.

In 2010/11, the Technical Research Agreement was replaced by a broader Austroads – ARRB Partnership Agreement. The following five core areas of research are now included in the agreement. The key criterion is that these are areas where ARRB maintains the key source of significant research expertise in the region:

- Asset Management
- Bituminous Surfacings
- Pavement Technology
- Network Operations
- Road Safety Engineering.

This report summarises and highlights how the research funds provided under the program were deployed by ARRB during 2010/11.

Austroads Fellowship

Austroads directly supports the development of research capability within the road industry through its Fellowship program. The Fellowship provides both financial and technical support for selected candidates to study for a postgraduate research-based degree of relevance to Austroads members at an Australian university. Candidates may be graduate students or experienced staff from road authorities or related organisations.

The second Austroads Fellow was Tony Matacin of the Queensland Department of Transport and Main Roads. Tony was awarded a Master of Engineering by Monash University in 2010 for his thesis on unbound granular pavement moisture response due to climate. This project was very topical given the extensive flooding along the eastern seaboard of Australia during 2010/11.

The third Austroads PhD Fellowship holder is Ryan de Carteret of the Roads and Traffic Authority of New South Wales. Ryan commenced his studies for a Doctor of Philosophy at the University of Newcastle in February 2010. Ryan's project is titled *Salinity and Road Pavements* and aims to determine the mechanisms and processes by which salts move and accumulate within road pavements, and to determine how salinity affects the performance characteristics of sealed unbound granular road pavements.

To date Ryan has undertaken a review of literature, designed and constructed a field trial site, designed and established an instrumented laboratory column study and commenced laboratory testing. Ryan's initial work was published and presented at the 24th ARRB Conference in 2010 and there will be further conference presentations during 2011. Ryan is currently on schedule to submit his PhD thesis in early 2013.

Capability within ARRB

A sustainable expertise model for research capability

Over the last two years, ARRB and its members (separately and collectively as Austroads) have been developing a strategy for ensuring that sustainable research expertise is available to the members in a few areas of critical interest to them. This Sustainable Expertise Model (SEM) was endorsed by the road agencies in December 2010.

Each critical area is covered by an expertise cell. The cell is intended to have nine researchers in it as a minimum; a Chief (or technical/scientific leader), two 'heirs' who are trained to replace the Chief, and six researchers varying in experience between graduate and those able to become an heir themselves. This configuration of the cell is considered to be the bare minimum required to ensure expertise is sustainable.

Each cell is supported by the necessary research infrastructure required to support the science undertaken in the cell. This infrastructure may be laboratory or testing equipment needed by the researchers and specific to the cell, or infrastructure in a broader sense, common to more than one cell, such as information/knowledge management services and researcher development programs.

A critical component of the SEM strategy is that the cells are staffed from ARRB, universities and road agencies, making best use of available research capability where it currently exists. Thus, while ARRB is required by its members to maintain these cells on their behalf and manage the research portfolio of each cell, a proportion of the researchers will be drawn from other institutions, in line with ARRB's original Articles of Association.

The SEM is focused primarily on research capability, but acknowledges that ongoing interaction with practitioners is needed to ensure practical outcomes of the research. The cells identified to be covered by the SEM are:

- asset management
- surfacings technology
- pavement technology
- network operations
- road safety engineering.

In the SEM, research infrastructure, like staffing, also operates as a distributed model with national coordination. ARRB currently supports this cell of the SEM in a number of areas, including:

- ARRB materials laboratories and pavement testing facilities
- leadership of national land transport information and knowledge services, through the work of the MG Lay Library and the National Interest Services (NIS) program
- ARRB's Knowledge Transfer program, assisting with translating research into practice through workshops that provide access to current knowledge and experts. Thirty-one workshops were presented to over 800 participants throughout Australasia during 2010/11 to promote knowledge based on the new Austroads Guides. The topics covered included geometric road design, traffic theory and applications, treatment of crash locations, and geotechnical investigation and design.

ARRB's professional development programs for researchers at various stages of their careers also contribute to the building of expertise available for Austroads projects. The table below provides a summary of current higher degree capability levels.

	ARRB staff with the following highest qualification	
Technical area	**PhD**	**Masters**
Asset management	2	7
Bituminous surfacings	3	1
Pavement technology	3	4
Network operations	3	-
Road safety engineering	-	6
Total	**11**	**18**

Asset Management

Challenges

The Asset Management research program was aimed at supporting and progressing Austroads strategic asset management priority – to minimise the whole-of-life cost of road and bridge assets to meet the transport task. In doing so the program tackled the following challenges:

- understanding network wear and cost implications of incremental load increases on axle groups
- achieving consistency in asset management decisions and inputs
- improving asset management decision-making capabilities.

Network wear and cost implications of incremental load increases on axle groups

Background

In support of the Council of Australian Governments (COAG) reforms for the phased introduction of pricing for increased axle loading for heavy vehicles, Austroads and the National Transport Commission (NTC) have sought a robust and transparent process for estimating the wear and cost impact of incremental increases on axle-load groups that allow increased efficiency for heavy road freight vehicles.

In 2010/11, research, based on the Austroads-funded project AT1394, was extended to the following tasks under Austroads, NTC and COAG Road Reform Plan (CRRP) funding:

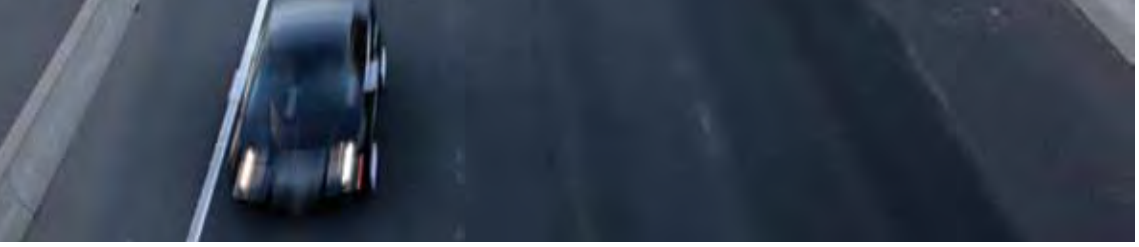
- estimation of the short-run marginal cost (SRMC) and long-run marginal cost (LRMC) of road wear in order to develop an engineering/economic model to estimate the marginal cost of road wear caused by heavy vehicles which will be used to develop indicative prices for several alternative pricing models being investigated
- further refinement of the freight axle mass limits investigation tool (FAMLIT), using the maintenance cost relationship with heavy vehicle road use combined with the Austroads rutting and roughness deterioration models and a strength/roughness deterioration model, to predict the life-cycle cost of road wear under increased axle loads
- development of a scoping document that outlined the approaches (engineering and econometric) to determining the marginal cost of bridge wear caused by heavy vehicle use as a basis to produce indicative prices as part of the CRRP initiatives.

Total pavement wear was assessed by using standard axle repetitions (SARs) to represent the traffic loading on each road type. Different load-wear relationships were used for different pavement types.

Load-wear cost relationships

Load-wear cost (LWC) relationships were the basis of estimating the SRMC and LRMC of road wear and were presented in terms of equivalent annual uniform costs (EAUC) using the discounted maintenance and rehabilitation costs for each road type and axle group on the sealed road network. The EAUC were determined to be a function of climate (Thornthwaite Index) and axle mass (tonne) and alternatively as a function of climate and SAR-km. The LWC relationships were derived using regression analyses of the FAMLIT outputs of EAUC at various loads.

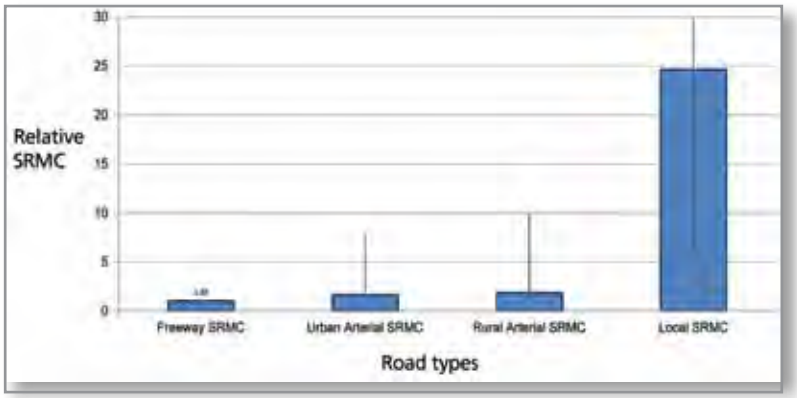
The SRMC and LRMC estimates of road wear were derived from the LWC relationships of EAUC versus axle mass and EAUC versus SAR. The SRMC and LRMC estimates were based on their impact on the original pavement strength. For SRMC, maintenance and rehabilitation was aimed at

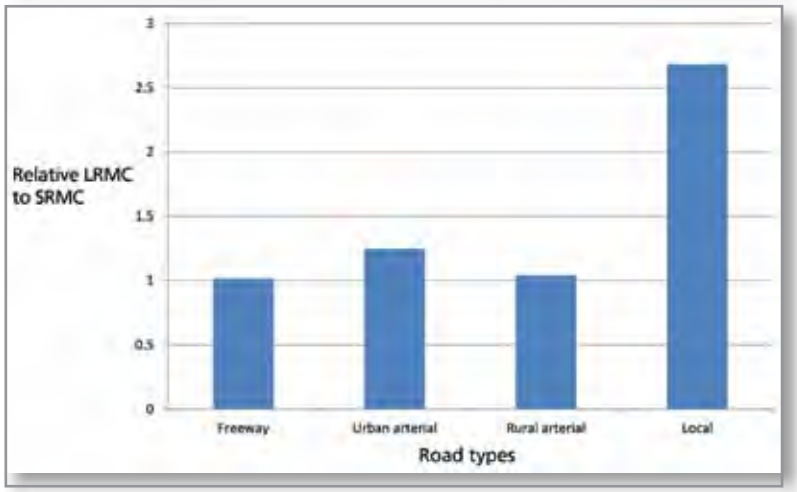


retaining the original pavement strength, while for LRMC, rehabilitation was aimed to increase the original pavement strength to meet the increased capacity requirements of increased axle loads.

The following figures show:

- the estimated short-run marginal cost relativities based on the average road wear derived from the rutting and roughness deterioration (RRD) models, and strength/roughness deterioration (SRD) models for four main road types (first figure)
- the relationship between short and long-run marginal costs for the four road types (second figure); long-run marginal cost estimates are always higher than short-run estimates.

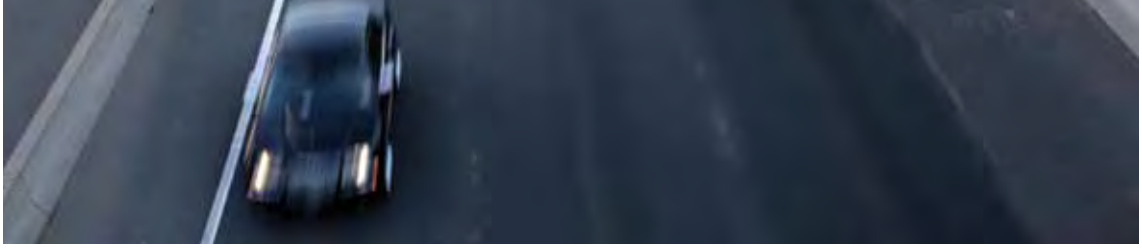




Consistency in asset management decisions and inputs

Making informed decisions relies upon transparent, robust and repeatable data. Austroads has long had a focus on identifying the data requirements for the road network to enable informed asset management decisions. As with the objectives of the Austroads Guides, there is continued emphasis to standardise data inputs and reporting outputs across Austroads members.

Common data sets provide benefits including the ability to leverage off economies of scale, harmonisation of approaches, benchmarking and enabling national initiatives and policy reform to be informed by real data. There is an ongoing need to consider the merits of collecting and reporting additional data to improve the understanding of network performance and more recently to provide a better basis for any future road user charging regimes.



Over the period of the Austroads – ARRB Technical Research Agreement a number of studies to enhance the standardisation and harmonisation of asset management data have been completed. Projects to review, enhance and establish data collection, processing and reporting practice included:

AT1631: *Review of the traffic speed deflectometer*
AT 1484: *Review of standard measures for collecting road condition data*
AT 1488: *Improving skid resistance measurement*
AT1489: *Determining the best measure of ride quality for heavy vehicles*
AT1491: *Update of road user and externality cost inputs and underpinning vehicle and road relationships.*

Descriptions of two of these projects are provided.

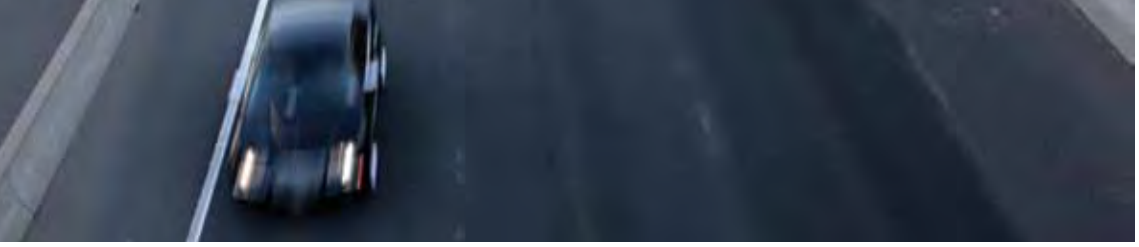
Review of the traffic speed deflectometer

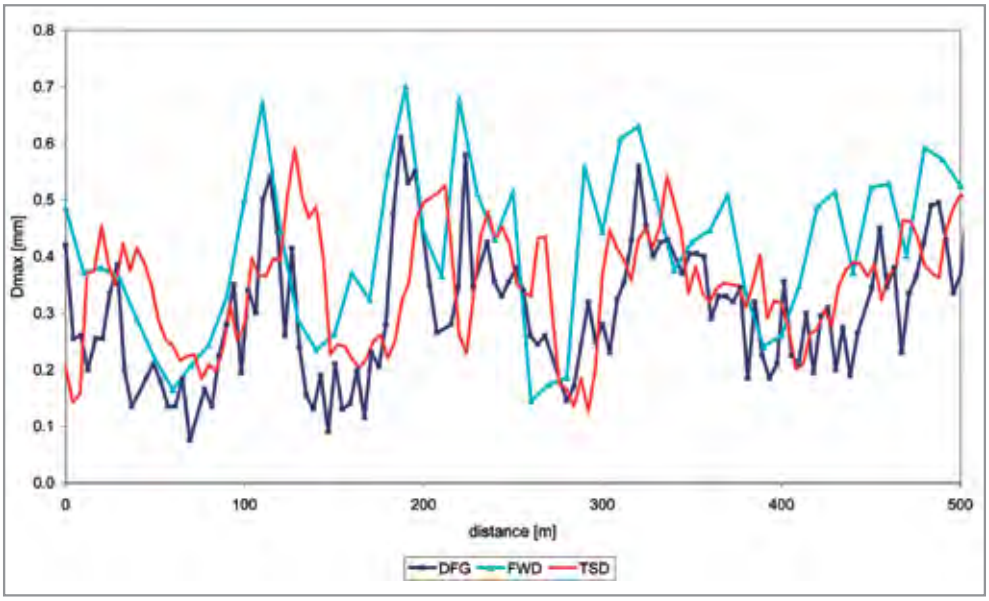
The traffic speed deflectometer (TSD) is an innovative device developed in Denmark that can measure the response of a pavement to an applied load at traffic speeds (i.e. 80 km/h). Traditional devices are slow and expose motorists and operators to road safety risks. This project was established to enable ARRB and Austroads member authorities to work with the New South Wales Roads and Traffic Authority (RTA) and Queensland Department of Transport and Main Roads (TMR) to develop an independent national perspective on the applicability of the TSD to Australian conditions and practices.

The RTA engaged the Danish Road Directorate (DRD) to bring its TSD to Australia. Some 18 000 km of the New South W ales and Queensland road networks were surveyed over the 2009/10 Australian summer. While preliminary assessments of the TSD indicated it could provide reliable and repeatable measurements on the mainly asphalt pavements encountered in Denmark, its performance on granular pavements like those typically encountered in Australia was unknown.

The project is a showcase for the collaboration of interested stakeholders to achieve the best research outcomes. Through its duration, in addition to the working group of Australian road authorities, the project team collaborated and worked with other researchers including the UK Transport Research Laboratory, the DRD research arm and the Federal Highway Research Institute (BASt) in Germany.

TSD configuration in Australia (Danish articulated trailer and container connected to an Australian compliant right-hand-drive prime mover)





Deflection results at Illawarra site 1 – deflectograph (DFG), falling weight deflectometer (FWD) and traffic speed deflectometer (TSD) at 60 km/h

Based on the findings of the project, it is apparent the TSD technology is effective and is capable of measuring a pavement's response to load at trafficable speeds. This is a revolution in pavement condition measuring technology. It is not, however, a mature technology with well-established test methods and equipment specifications. Findings have demonstrated that survey results are subject to a number of known and unknown influences, and robust quality management of survey operations and data processing is essential to the effective adoption and implementation of the technology.

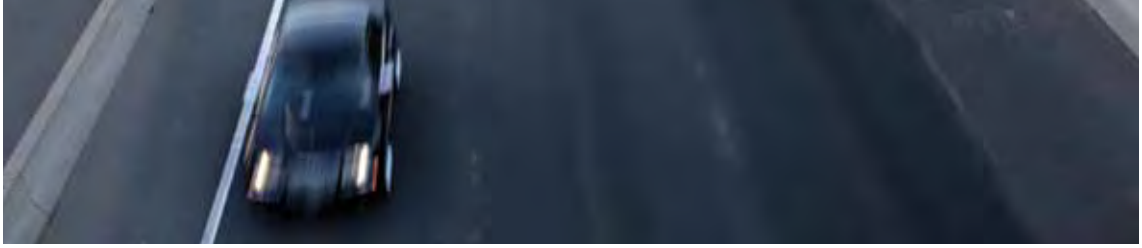
The research supports the applicability of the TSD to Australian conditions. Based on the current assessment, the TSD has the following attributes:

- can be used as a network-level screening tool to identify suspect pavements within a network and to target follow-up testing with traditional devices
- shows considerable immediate promise as an input into the design of granular overlays on existing granular pavements, which represent the majority of the length of the rural road network in Australia and New Zealand; however, the use of TSD data for the design of flexible overlays on other flexible pavement types is not considered currently possible
- offers a significant reduction in traffic disruption and hazard exposure for operators over traditional devices
- provides significantly more intensive data than existing systems at higher production rates and reduced costs.

If a TSD is procured for Australian use the specification should be developed in collaboration with other researchers and operators, data users, and future Australian users of TSD data to access the most recent knowledge in TSD applications and confirm the optimal configuration of the equipment for Australian conditions and practices.

Determining the best measure of ride quality for heavy vehicles

Currently, many agencies use the International Roughness Index (IRI) roughness measure to trigger pavement rehabilitation works. It is known that since IRI is based on a car model it does not



adequately represent the ride quality experienced by heavy vehicles; however, agencies lack the means to assess roughness for heavy vehicles as quickly and easily as IRI does for cars.

This project was established to investigate various means of measuring road roughness and their correlation with ride quality as experienced by the driver of a heavy vehicle. The outcome is expected to either endorse an existing index or lead to the development of a new ride quality index.

The results to date quantify the effect of different configurations (vehicles, suspension type, loading and additional trailers) on the ride quality as experienced by the driver, as well as measuring the vertical vibrations at three points (chassis, cab floor and seat) as they travel through the vehicles. Since a vehicle and driver is a very complex system, explanatory results have not yet been obtained; however, interesting correlations have emerged. The development of a heavy vehicle roughness band index appears likely in 2011/12.

Long-term pavement performance studies

This project monitors the long-term pavement performance (LTPP) sites and long-term pavement performance maintenance (LTPPM) sites to study the effect of traffic, various maintenance treatments and environment on the performance of a number of road pavement types around Australia.

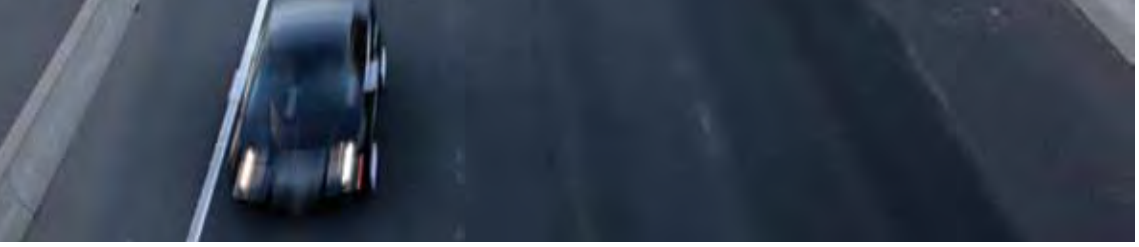
In 2010/11 a scoping document for the development of probabilistic road deterioration models was drafted and a review of the AASHTO Pavement Design Guide Performance Relationships was undertaken in addition to the annual monitoring of the LTPP/LTPPM sites.

Towards developing a relationship between road maintenance expenditure and heavy vehicle road use

A national database containing clearly identified pavement segments with pavement related maintenance data and associated road use information has the potential to assist in the development of relationships between road maintenance expenditure, or road wear cost, and road use. Road maintenance expenditure is comprised of various forms of road wear cost, such as routine and periodic pavement maintenance and rehabilitation. Relationships between road wear cost and road use are a fundamental basis for road track cost allocation in refining and setting heavy vehicle road user charges.

Phase 1 of this project assembled Auslink national highway data on road condition, maintenance expenditure and road use from Queensland, New South Wales, Victoria and South Australia. This data was grouped into 'families' within each state using a minimum message length (MML) statistical approach so that each family had common data associations. Analysis of the data within the families of the pavement periodic maintenance expenditure and road use data, under typical in-service pavement conditions, allowed the development of highly probable relationships between periodic maintenance expenditure and a road use variable, SAR-km. When separated into the variable portion of maintenance expenditure, the results obtained were comparable to those obtained on previous independent datasets of pavement maintenance and road use.

Phase 2 assembled data on road condition, maintenance expenditure and road use on a wide range of arterial road samples from Queensland, New South Wales, Victoria and South Australia to develop relationships between periodic maintenance expenditure and a road use variable on the basis of the above MML approach. These relationships were developed based mainly on the very large dataset from Queensland, which again confirmed the use of SAR-km as the road use variable to predict periodic maintenance expenditure.



Asset management national performance indicators

This project was aimed at establishing the basis for a new set of network performance indicators (NPIs) for asset management of the road network. An initial workshop was arranged to set the framework for the selection and evaluation of the new NPIs. A draft report was completed setting out a range of performance indicators proposed for pavements and drainage, safety, the environment and efficiency.

A further workshop was undertaken in April 2010 to finalise the NPIs which developed a combined performance indicator (CPI) for pavement condition based on individual condition indices for roughness, rutting, cracking and deflection. The NPIs for drainage conditions, the environment, safety and efficiency need further development and refinement to meet the broad reporting needs of member authorities.

Development of marginal costs for heavy vehicle bridge usage

A scoping document was drafted to outline the approaches (engineering and econometric) to determining the marginal cost of bridge wear caused by heavy vehicle use as a basis to produce indicative prices as part of the COAG Road Reform Plan initiatives. The engineering approach relies on sound estimates of road use data for each bridge sample and reliable deterioration models which do not currently exist. The quality of road use data that is required is similar to that collected at weigh-in-motion (WIM) sites. Given the limited number of WIM sites in the network this means that estimates need to be made for bridges remote from WIM sites.

The econometric approach may have limited value in terms of providing a sound basis for estimating marginal costs. If further research is undertaken on a limited number of bridges in a state where the cost and road use data is more reliable, the econometric approach would provide a point of comparison with the engineering approach.

At this stage it has been decided not to proceed with the estimation of the marginal cost of bridge wear due to the lack of adequate data and sound bridge deterioration models.

Selected outputs from the Asset Management research program in 2010/11

Publications available from Austroads publications website: www.onlinepublications.austroads.com.au

Network performance indicators: next generation, Chin, Martin, Robinson, Thoresen, Evans (AP-T176/11)

Review of the specifications for the collection of digital road imaging, Chen (AP-T169/10)

Other outputs

Experimental estimation of the relative deterioration of flexible pavements under increased axle loads, International Journal of Pavement Engineering, Vol 12, No 1, 2011, Martin (Austroads project AT1064)

Heavy vehicle road wear on sealed unbound granular roads, Proceedings of the Institution of Civil Engineers, Vol 164, No TR1, 2011, Martin (Austroads projects AT1064 & AT1337)

Modelling the marginal cost of road wear, research paper, National Transport Commission, Melbourne, 2011, Clarke, Kelley, Sandhu, Porter, Martin, Thoresen, Hore-Lacy (Austroads project AT1394)

Pavement performance: what is known and what is unknown, ARRB Conference, 24th, 2010, Melbourne, Martin, Choummanivong, Thoresen (Austroads project AT1064)

Bituminous Surfacings

Challenges

The Bituminous Surfacings research program aims to ensure sustainability of road construction and road maintenance operations, together with sustaining the high-level technical capability at ARRB in this critical area.

Bituminous sciences expertise

During the year ARRB appointed a specialist in bituminous sciences with over 20 years of post-doctoral experience in universities, CSIRO and industry. He was formerly Australian bitumen technology manager at a major multinational bitumen company. ARRB also appointed a new laboratory manager who has been successful in combining the different laboratories into one functional group and streamlining laboratory processes. These changes were necessary to ensure that the ARRB bitumen, asphalt, pavement materials and concrete laboratories can strive to be the benchmark for professionalism and accuracy in Australia.

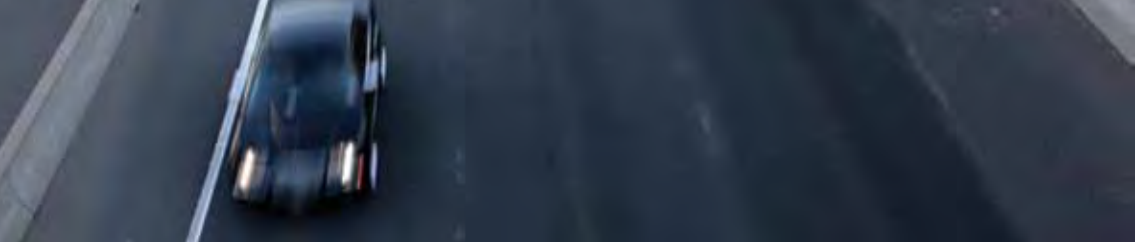
The bituminous surfacings work program aims to address research needs in the areas of bitumen and polymer modified binders, asphalt and sprayed seals. The research involves laboratory testing and development of test methods, theoretical analysis, field trials and validation trials. The research process provides training and experience necessary for development and maintenance of expertise, and the outputs of the research support improved practice, specifications and standards.

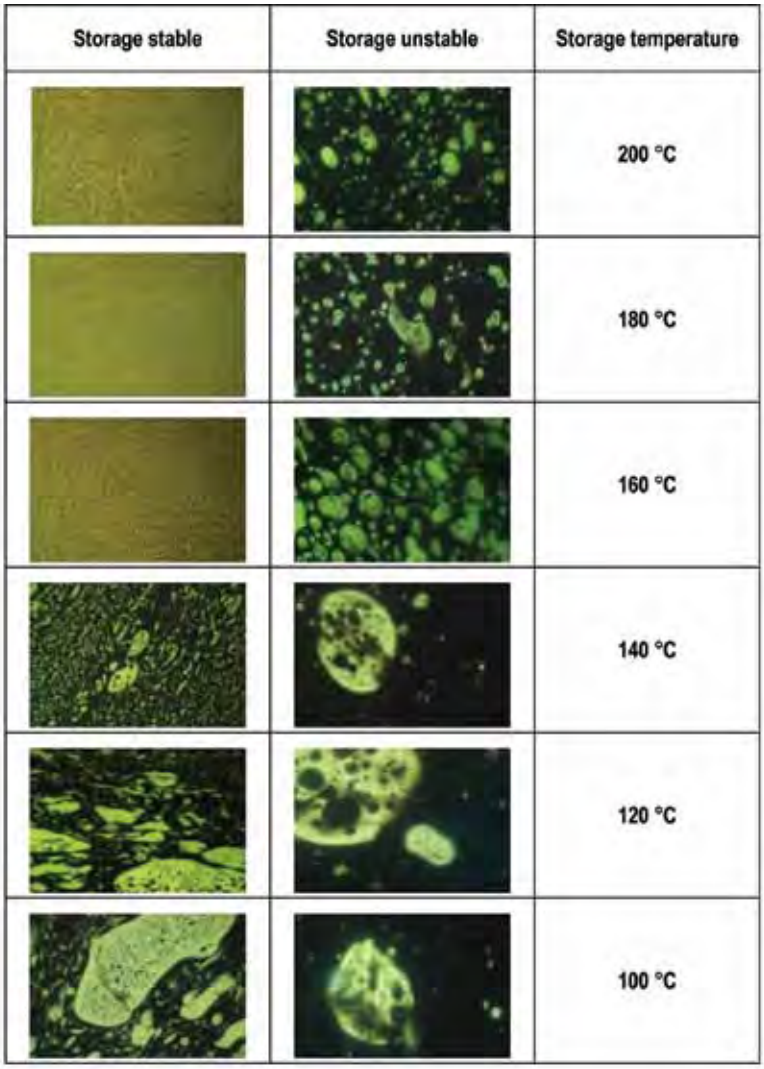
Testing of bitumen samples

ARRB continued to test bitumen samples currently used by Australian jurisdictions. This work is important as the proportion of bitumen refined in Australia (where refineries manufacture solely to Australian specifications) has continued to decline and the bitumen sourced from various refineries in South East Asia (where refineries manufacture to a variety of specifications) continues to increase. It should also be noted that the Australian Standard for bitumen is now more than 10 years old and needs to be reviewed or re-issued.

Further to discussion at the June 2010 Austroads Board meeting, ARRB in consultation with the Program Manager Technology prepared a short summary paper on bitumen supply in Australia. The paper identified closure of Australian refineries, a trend to importation of overseas bitumen (including by smaller companies as well as major companies) and changes to the way bitumen is transported which may affect its properties. The survey found that some jurisdictions do not undertake any specification compliance testing, with most jurisdictions relying on supplier quality systems and test certificates.

Research into polymer modified binder (PMB) morphology has found that 5 out of 12 commercially produced PMBs tested showed significant issues with regard to segregation and degradation. This is particularly important to jurisdictions that must transport their PMBs over long distances involving extended transportation time and vibration. These preliminary findings



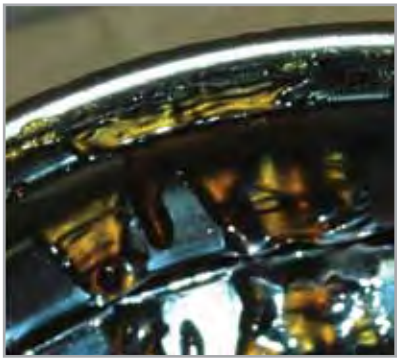


Epifluorescence microscope photographs showing the morphology of a storage stable and a storage unstable polymer modified binder, 0.08 x 1.2 mm

were communicated to jurisdictional representatives present at the technical reference group meeting, and an Austroads technical report has been submitted for publication.

Alternative surfacing binders

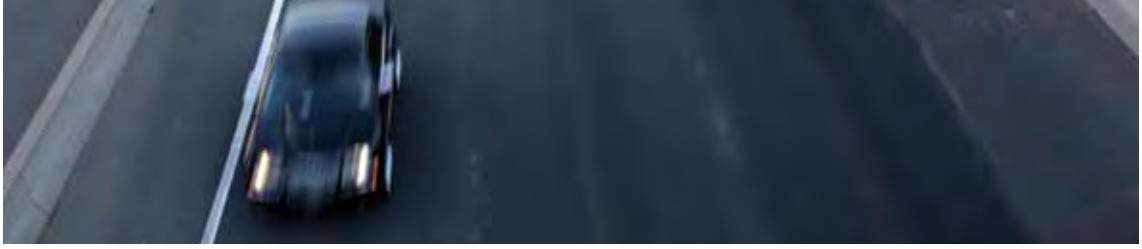
A project is investigating the future availability and increasing cost of bitumen or alternative surfacing binders. Samples of two bitumen replacement binders have been sourced from France and the UK and have currently undergone laboratory testing. Samples of bitumen extenders have been sourced from New Zealand and the USA, and have also undergone laboratory testing. A field trial of the more promising products is planned for the coming year.



A bitumen alternative from France manufactured from plant-derived components

Sprayed sealing

In the sprayed sealing area, an improvement to the double/double seal design method has undergone significant reference group review,



and is now ready for publication. Ongoing analysis of the behaviour of the double/double seal under the Accelerated Loading Facility has identified some unexpected trends in the effects that different axle groupings (single, tandem and tri-axle groupings) have on sprayed seal wear. These preliminary findings will be further investigated and may help further improve sprayed seal design for heavy vehicle loadings.

Following extensive consultation with industry, a revised bitumen sprayer specification based on the output performance rather than prescription of the input, was published to replace the 1989 edition.

Sprayed seal conference technical demonstration – synchronised spraying of binder and spreading of aggregate

2nd International Sprayed Sealing Conference

The 2nd International Sprayed Sealing Conference was held in October and involved over 240 participants from 19 countries. The theme was *Sustaining sprayed sealing practice*. It featured a technical tour, 3 paper sessions (involving 15 refereed papers) and 3 special sessions. The Conference keynote address was delivered by Mr Dennis Rossmann (South African National Roads Agency) on *Imperatives in sustaining sprayed sealing practice*.

Stone mastic asphalt

In the asphalt area, work has continued on the review of stone mastic asphalt (SMA) compaction and permeability issues, along with a review of SMA-like mixes with high texture. A report on the influence of compaction on the performance of dense graded asphalt has been completed. The initial findings of the AAPA/Austroads warm mix asphalt (WMA) validation project are being reported.

Warm mix asphalt

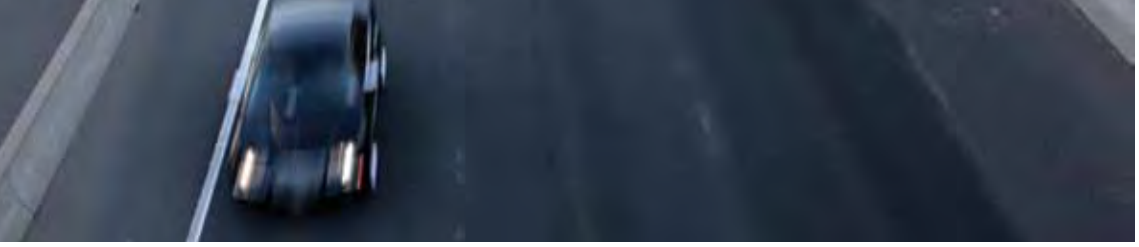
The performance of warm mix asphalt is another area of vital interest to member authorities. A construction report including laboratory test results for the warm mix asphalt trial recently laid by AAPA members in Melbourne is currently being collated with the assistance of industry.

Skid resistance

The most recent highlight is the publication of Austroads *Guidance for the Development of Policy to Manage Skid Resistance* which gained sign-off from all jurisdictions. Skid resistance research is continuing now in the areas of calculating investigatory levels and in national harmonisation in measurement reporting.

Polished aggregate friction value is an Australian aggregate characterisation test that is used by many jurisdictions for managing skid resistance at the network level. Due to the large variations within each test, each new aggregate must be tested

ARRB's vertical-wheel aggregate polishing



alongside a 'reference' stone, for calibration of the result. After about 20 years of use, the supply of Australian reference stone (originally expected to last only for 10 years) has been depleted and an alternative reference stone is required. The most cost-effective option is the adoption of the British reference stone (which is considered to be the international standard). Work commenced on the procurement and correlation exercises required to facilitate this change.

Selected outputs from the Bituminous Surfacings research program

Cutter contents for PMB seals, Oliver (AP-T180/11)

Elastometer upgrade and commissioning, Choi (AP-T173/10)

Guidance for the development of policy to manage skid resistance, Neaylon (AP-R374/11)

Laboratory study on relationship between binder properties and asphalt rutting, Choi (AP-T164/10)

Measurement of changes in PMBs during transport and storage: a pilot study, Oliver, Khoo (AP-T166/10)

Performance requirements for bitumen sprayers, Holtrop, Neaylon (AP-T181/11)

Review of primes and primerseal design, Busuttil, Sharp, Neaylon (AP-T179/11)

Review of skid resistance and measurement methods, Choi (AP-T177/11)

Second national survey of Australian bitumens, Oliver (AP-T182/11)

Other outputs

Towards a harmonised Australian approach for managing skid resistance, ARRB Conference, 24th, 2010, Melbourne, Neaylon

Photo: K. Y. Khoo

Challenges

The Pavement Technology research program is aimed at tackling the following challenges:

- increasing pressure to allow larger loads to increase freight efficiency
- increasing scarcity of quality road building materials
- minimising whole-of-life pavement costs.

Pavement impacts of vehicles with higher freight efficiency

Influence of axle load increases

There is growing pressure to increase heavy vehicle axle-group loads to continue the improvement in freight efficiency that has occurred in recent years with the introduction of larger vehicles such as B-doubles and B-triples. However, the effects of loads on pavement wear, and hence road agency maintenance costs, need to be well understood.

In work undertaken in the previous years, it was observed that the fatigue life depended upon the breaking strain of a material rather than its initial flexural modulus. This dependence is not reflected in the existing Austroads performance relationship, but is common to many relationships used internationally. In addition, there was a difference in performance characterisation measured in the laboratory and in service. This may be related to the larger amount of non-load-related micro-cracking of cemented materials in service.

In 2010/11 research commenced on modifying the laboratory fatigue testing method to better reflect in-service fatigue performance. A large number of test beams were manufactured and fatigue testing commenced using a new procedure to induce micro-cracking in the laboratory beams prior to fatigue testing. This testing program will continue in 2011/12.

Influence of multiple axle loads on pavement performance

Austroads and the National Transport Commission (NTC) have continued to make progress in establishing new performance based standards (PBS) for heavy vehicles, including pavement vertical loading. Additionally, there is interest in incremental pricing whereby heavy vehicle

Photo: M. Moffatt

Excavation of a test section after Accelerated Loading Facility trafficking

Austrack – new slab compactor and large-scale wheel tracking device (courtesy of IPC Global)

axle-group loads would be permitted to exceed current prescriptive limits based on paying for the additional road wear. These developments have highlighted the need for improved knowledge about the impact of axle-group types as current information is very limited.

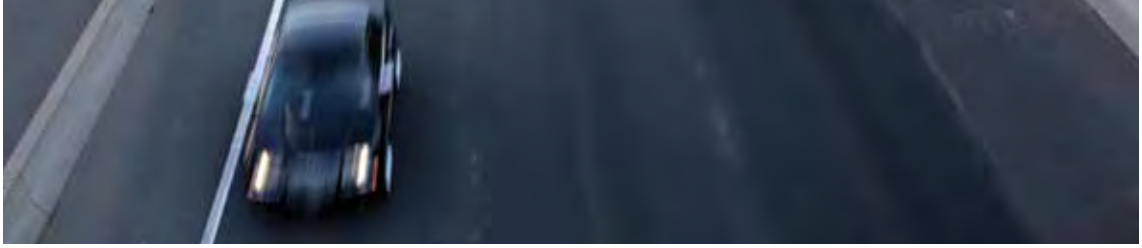
A laboratory testing program to examine the effects of multiple axle loads on asphalt fatigue performance has been prepared. Significantly, the development of this program was influenced by direct meetings with researchers from Michigan State University (USA), Laboratoire Central des Ponts et Chaussées, LCPC (France), and the Federal Highway Research Institute (BASt) (Germany). The fatigue testing program will commence in 2011/12.

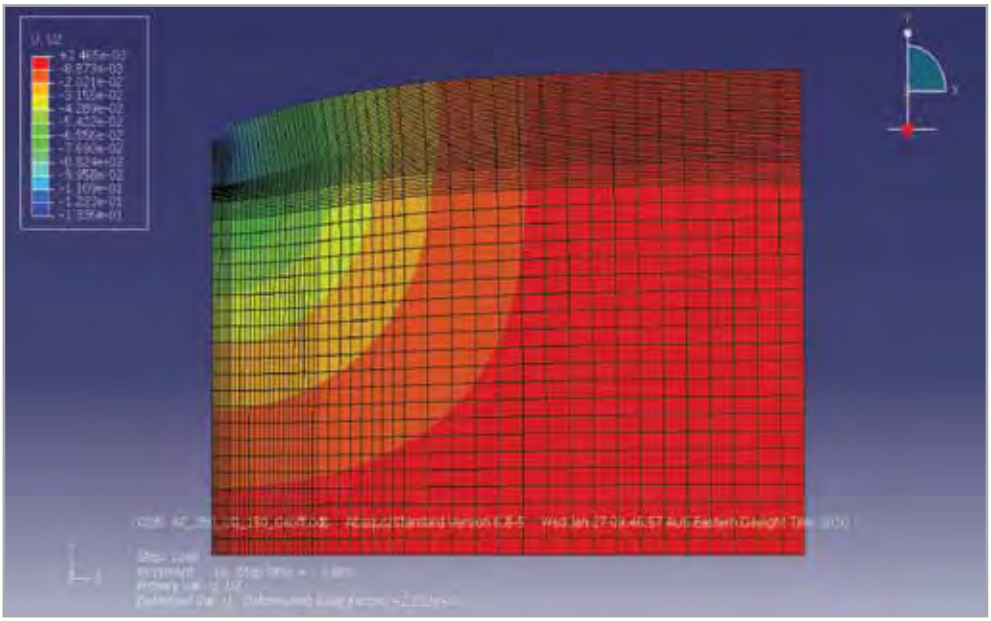
In parallel, accelerated testing of a typical unbound granular rural highway pavement is being undertaken using the Accelerated Loading Facility (ALF). Modifications have been made to the ALF machine to enable it to apply tandem and tri-axle loads. In 2009/10 over one million cycles of ALF loading were applied using single, tandem and triaxle axle groups, and the performance of the pavement observed. In 2010/11 a further 1.8 million cycles of loading were completed. In 2011/12 the final series of experiments will be completed and analysis of all the project data will commence.

Materials scarcity

Over the last decade a considerable amount of research has been focused on the development of a repeated load triaxial (RLT) test procedure to assist practitioners in the use of natural and marginal unbound base/subbase materials in road pavements. A significant hindrance to the widespread adoption of the RLT test has been the lack of data linking the results of the laboratory test to field performance. In order to address this issue, test pavements have previously been constructed and loaded with the ALF, and comparison of the observed rutting made with laboratory testing using the RLT test.

Work in 2010/11 centred on commissioning a new slab compactor and large-scale wheel tracking equipment suitable for assessing the rut resistance of both asphalt and unbound granular





Example of vertical displacement output (U2) calculated for a 2D, axisymmetric finite element mesh

materials. Rut resistance is assessed by applying up to a 5–10 kN load to a pneumatic tyre. A test method for assessing the rut-resistance of granular materials will be developed In 2011/12.

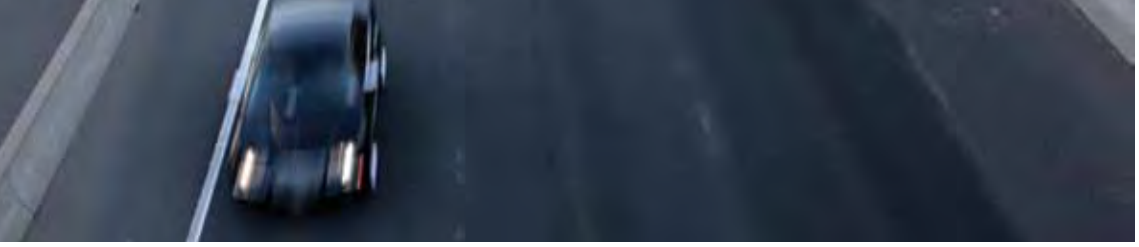
Minimising whole-of-life pavement costs

With increasing demands on the road network due to the increasing freight task, it is critical that costs to construct and maintain pavements are minimised. The procedures used to design pavements have a significant impact on these costs.

Recognising the need for an improved ability to predict the performance of thin bituminous surface unbound granular pavements and the benefits in performance prediction that would result from the development of a finite element response to load model, Austroads established a research project to develop an improved Austroads model. This multi-year project is being undertaken in collaboration by ARRB and the University of New South Wales.

In 2010/11, the development of a two-dimensional non-linear finite element pavement response to load model (AustPads) was completed. This enables more realistic characterisation of elastic characteristics of unbound granular materials and subgrade than is possible with the current Austroads linear elastic response to load model.

In 2011/12, research will commence to assess the potential of AustPads to provide an enhanced ability to predict the rutting of thin bituminous surface unbound granular pavements.



Selected outputs from the Pavement Technology research program in 2010/11

Publications available from Austroads publications website: www.onlinepublications.austroads.com.au

Guide to pavement technology: part 2: pavement structural design, Jameson (update - in press)

Guide to pavement technology: part 5: pavement evaluation and treatment design, Jameson (update - in press)

Other outputs

Assessment of rut-resistance of unbound granular bases, International Conference on Asphalt Pavements, 11th, 2010, Nagoya, Japan, Jameson, Vuong, Moffatt

Crushed brick blends with crushed rock for pavement systems, Proceedings of the Institution of Civil Engineers: Waste and Resource Management, Vol 163, No 1, 2010, Aatheesan, Arulrajah, Bo, Vuong, Wilson

Development of non-linear finite pavement response model, Gonzalez, Bodin, Jameson, Oeser (Austroads project TT1452)

Feasibility of using in-service pavement performance data to determine the fatigue characteristics of foamed bitumen stabilised pavements, Jameson (Austroads project TT1633)

Field trials of constructibility and performance of recycled granular base materials with glass additive, ARRB Conference, 24th, 2010, Melbourne, Vuong, Choumannivong, Luke, Newman, Denham, Arulrajah, Ali

Improved rut resistance of granular bases: manufacturing and commissioning of wheel tracking device, Bodin (Austroads project TT1611)

Prediction of reflection cracking resistance of reinforced asphalts, ARRB Conference, 24th, 2010, Melbourne, Vuong, Hoque, Choi

Photo: V. Jaeger

Network Operations

Challenges

The Network Operations research program focused on tackling traffic congestion which is the interaction of demand and capacity in the movement of people, goods and services, travel time reliability, mobility and economic impacts. Its aim is to improve the productivity and reliability of the road network in moving people and goods with emphasis on:

- operational performance
- travel demand management
- improving the levels of service to specific users.

Photo: V. Jaeger

Four project themes are highlighted and a list of selected publications related to these themes is also included.

Network performance measurement

Since the mid-1990s, the National Performance Indicator (NPI) Program has employed floating-car surveys to measure travel times on representative routes a few times a year as a means to monitor the performance of a road network in a jurisdiction. In recent years, some jurisdictions felt that the limited amount of survey data in the NPI program is insufficient and may not present a true picture of prevailing traffic conditions, especially in the larger cities where congestion and peak-spreading are common. Further, some jurisdictions have also started measuring traffic performance online on freeways and arterials with the use of vehicle detectors in freeway management systems (FMS) and in signal area traffic control systems.

Projects NS1207, NS1376 and NS1585 developed a common data collection and reporting framework. This framework has now been implemented in the STREAMS platform of the Queensland TMR, and will be progressively implemented in the freeway management systems and SCATS traffic systems nationally.

Balancing traffic density in a congested network

Congestion in Australian cities has continued to get worse with significant increases in population and new car registrations – about a million new motor vehicles per year before and after the global financial crisis in 2008/09. Area traffic control (ATC) systems such as SCATS or STREAMS are essential tools to manage congestion on arterial roads. It is important that the operation of these systems continues to deal effectively with increasing congestion, and manages competing demands for limited road space.

Photo: V. Jaeger

At present, ATC systems in Australia and New Zealand employ mostly information from one set of detectors on a road link for signal operations. These detectors are near the stop line and both SCATS and STREAMS do not generally employ detectors at the upstream end of a road link. An extra set of upstream detectors on an arterial road link would be beneficial in providing useful data for the measurement of network performance and adaptive traffic control. However, detectors are expensive to install and maintain. New software for queue formation and dissipation needs to be developed.

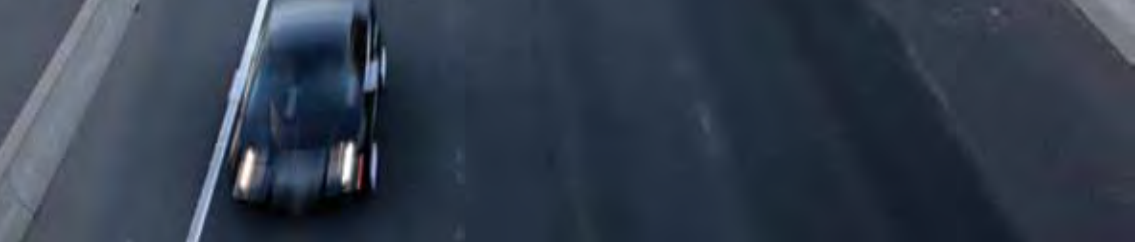


Photo: V. Jaeger

Project NT1590 successfully employed microsimulation to identify some principles underlying the implementation of pre-emption and gating schemes in an ATC system. It was recommended that road agencies begin by utilising more of the existing detectors and not just from a specific intersection but also from one or more intersections upstream and downstream.

Increasing congestion levels on arterials have also heightened the conflict in the allocation of road capacity to on-road public transport (ORPT) and general traffic. The application of ORPT priority is increasingly being considered by road agencies, with the intent of improving travel time and travel time reliability of ORPT, while minimising negative impacts on general traffic. Project NT1528 examined the performance of several ORPT priority schemes using microsimulation and suggested guidelines on scheme selection and design. It was recommended that road agencies continue to refine and expand existing guidelines on ORPT priority treatments.

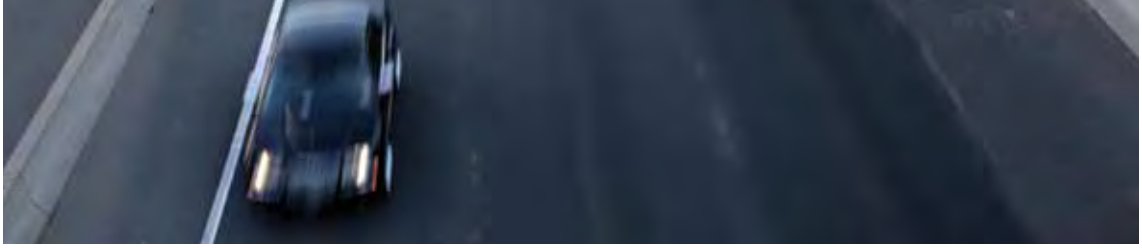
Development and application of accessibility measures

Accessibility is broadly defined as the variety of opportunities provided to people through efficient arrangement of land use and the provision of transport. It can be regarded as a framework that integrates the two sides of a coin, with efficiency on one side and land use on the other. Accessibility is an essential metric to assist in land use/transport planning and performance monitoring.

The ARRB accessibility metric or AAM was formulated in this project. The AAM includes four types of accessibility by mode, namely car, public transport, cycling and walking. It also includes accessibility to four destination types – work, primary and secondary school, tertiary institutions, and shopping and recreation. The AAM was calibrated to Australian metropolitan conditions.

Photo: W. Hore-Lacy

The application of the AAM was carried out at the strategic level in Perth and Melbourne. Generally, the CBD and its neighbouring areas were rated to have the best accessibility in metropolitan areas. However, areas of good accessibility could be observed in the suburbs, particularly for primary and secondary schools, and shopping and recreation. It was found that higher accessibility generally results in less travel kilometres and there was an indicative relationship between accessibility and property price.



AAM was further applied at the neighbourhood level in Joondalup (WA), Mandurah (WA) and Burwood Heights, City of Whitehorse (Victoria).

Application of information and communication technologies for network operations

This project theme represents the interaction of several disciplines (information technology, telecommunications, traffic engineering) in the general area of intelligent transport systems (ITS).

Project NS1510 aimed to employ a modular, open and scalable architecture to develop a new generation of signal controllers. Discussions with local manufacturers suggested that they welcome the approach and looked forward to participating in future research and development projects for implementation and type approval.

Project NS1520 investigated the latest communication technologies for ITS, e.g. linking traffic signals. The project team is in contact with the National Broadband Network Co., which can work directly with road agencies on the deployment of the national optical fibre network for ITS.

Project NS1632 (and the earlier NS1415) developed a road map for the future deployment of dedicated short-range radio communication technologies to improve road safety and travel efficiency. This is by means of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication and control.

Selected outputs from the Network Operations research program

Publications available from Austroads publications website: www.onlinepublications.austroads.com.au

Balancing traffic density in a signalised network, Luk, Green (AP-R369/10)

Freeway incident detection: technologies and techniques, Luk, Han, Chin (AP-R364/10)

Modelling of signalised intersections: case study, Espada, Bennett, Luk (AP-R365/10)

Other outputs

As this was the first year that the Network Operations research program was included in the Austroads – ARRB Partnership Agreement, a number of recent publications are listed rather than those for 2010/11 only.

A comparative study of four network operations planning frameworks/guidelines, ARRB Conference, 24th, 2010, Melbourne, Weeratunga, Luk

Automatic freeway incident detection: review of practices and guidance, ARRB Conference, 24th, 2010, Melbourne, Luk, Han, Chin

Freeway design parameters for fully managed operations, Australian Institute of Traffic Planning and Management (AITPM) National Conference, 2010, Brisbane, Green, Somers

Guidelines for selecting techniques for the modelling of road network operations, ARRB Conference, 24th, 2010, Melbourne, Espada, Luk, Yoo

Identifying a reference performance level to calculate congestion delay, Road and Transport Research, Vol.17, No 3, 2008, Luk, Han

New performance indicators for network operations using real-time traffic data, Road and Transport Research, Vol 17, No 3, 2008, Walsh, Su, Luk

Photo: R. Yeo

Challenges

The Road Safety Engineering research program is aimed at tackling the following challenges:

- provision of a safe road system
- prioritisation of activities aimed at creating safer roads and roadsides
- issues related to speed management and road safety.

Road safety engineering risk assessment

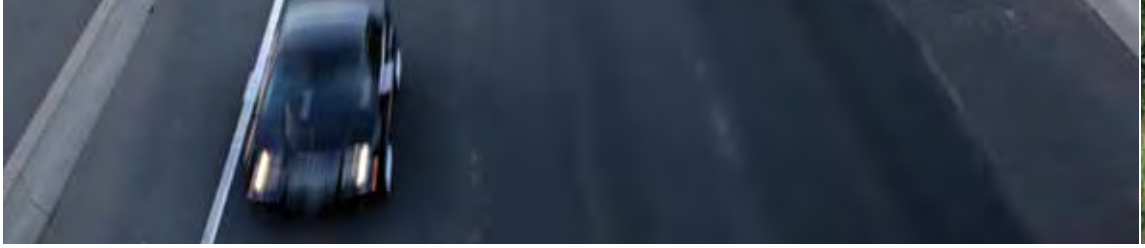
A major topic of research conducted under the technical research/partnership agreements has been on road safety engineering risk assessment. This research program has spanned the duration of the research agreement and covered a variety of topics relating to road infrastructure and safety. The research was aimed at better defining the relationship between road elements and crash risk, and providing methods, tools and information to better address risk on the road. The research program has culminated in a fundamental change in the way in which road safety risk is assessed in Australia and New Zealand. The approach has evolved from a process that relied on the prior occurrence of crashes to treat risk, to one that can also proactively assess risk before crashes occur. Eleven external reports have now been produced on this topic as well as 15 newsletters. The research has gained international recognition, and forms the basis of tools developed at the international level to address road safety risk.

National risk assessment project

This project's major objective is to develop a nationally agreed crash risk assessment model, to develop an implementation guide for its adoption by road authorities and to propose road safety funding program guidelines based on crash risk assessment. Further, the project aims to review and trial the effectiveness of priority road safety treatments. The project will also produce a stand-alone guide to the evaluation of road safety treatment effectiveness.

The project, which builds on the road safety engineering risk assessment work identified above is now in its second year. Significant progress has been made with the completion of a prototype

Photo: W. Hore-Lacy



of the Austroads National Risk Assessment Model (ANRAM), and the development of a stand-alone report on a standard approach to evaluation of treatment effectiveness, for adoption by road authorities.

Improving roadside safety

This is the third year of a program of research aimed at gaining a greater understanding of how to best manage and treat roadside hazards. This year's component of the study examined the effectiveness of safety barriers in reducing road trauma, identified the safety benefits of substituting unforgiving poles with frangible alternatives, and continued to investigate the effectiveness of clear zones.

Consultation with road authorities involved a review of findings and methodologies for the remainder of the project. The results from this project will be of high interest to road authorities in assessing risk for roadsides, and in identifying the most appropriate actions to address this risk.

Photo: J. Best

Methods to achieve overall reductions in operating speeds in rural areas

This research is aimed at identifying and providing information to road safety professionals on appropriate treatments for use on high-speed rural roads that might bring about reductions in speed and subsequent improvements in safety. Techniques for reducing speeds across the rural road network, and at specific locations on rural roads (e.g. at bends, intersections and the entry to townships) have been investigated, and information provided to road authorities on their use. A number of treatments that have not been used widely (or at all) in the past are now being trialled. The results of this work will form the basis of guidance to road authorities.

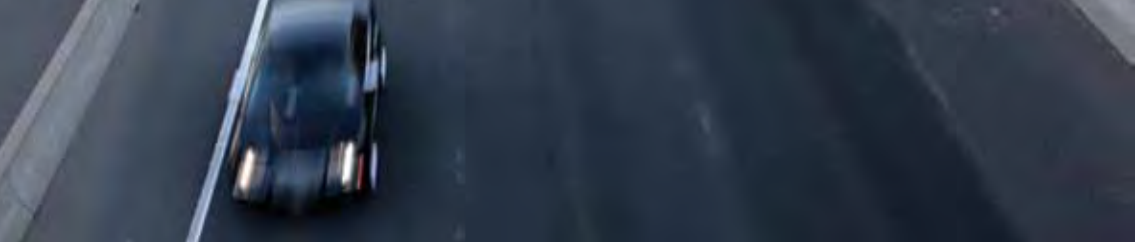
Safe speeds at intersections

This study sought to identify ways of reducing speeds on the approach to, and through intersections. A previous literature review of factors influencing speeds at intersections, an analysis of casualty crash data and inspections of relevant intersection crash sites had indicated some promising treatments. Additional evidence was gathered from various intersection speed management treatments implemented in Australia and New Zealand.

The review indicated that composite treatments, utilising a combination of various devices, achieve reductions in speeds on the approach to rural intersections; vehicle activated signs, particularly in association with reduced legal speed limits and other enhanced signing, assist in reducing approach speeds at rural intersections; in urban locations, treatments of street lengths or local areas, not just intersection sites, are associated with reduced speeds on local streets and potentially on the approach to local street intersections; and vertical displacement devices such as speed cushions and raised pavement areas are associated with speed reductions on the approach to local street intersections in urban areas.

Development of Austroads safety tools

ARRB has been actively involved in the development of tools to provide guidance to road safety engineers and other professionals. Aside from the Austroads Guides, a number of web-based applications have been developed.



The *Road Safety Audit Toolkit* (www.rsatoolkit.com.au) is an online tool that assists practitioners in conducting audits in accordance with the Austroads Road Safety Audit Guide. Since its first release (2004), the toolkit has evolved to include improved functionality and features, including group accounts, the ability to transfer audits, inclusion of photos and prompting users for commentary where a safety issue is identified. It was initially developed in line with the checklist questions from the 2002 Austroads Road Safety Audit Guide, and was updated to reflect the 2009 Guide. The toolkit also includes relevant references to design standards and guidelines from throughout Australia and New Zealand that provide ready assistance to users. ARRB continues to host the toolkit and provide support for it.

The *Road Safety Engineering Toolkit* (www.engtoolkit.com.au) is an online tool that assists practitioners by offering guidance on general road environment safety treatments for common crash types and engineering deficiencies. The toolkit draws together existing road safety engineering knowledge – this enables easy access to key information. The knowledge has been updated with experience from local and state government agencies, and with the results of comprehensive road safety research reviews. Since its first release, the toolkit has evolved to improve functionality and usefulness for practitioners, including incorporation of a range of additional treatment types and information on safety deficiencies. The value of this toolkit has been recognised internationally and, with Austroads permission, an international version (designed for use in developing countries) has been produced.

Heavy vehicle safety in urban areas

Over two-thirds of casualty crashes involving trucks in Australia occur in urban areas. Concern about heavy vehicle safety has been heightened with predictions that heavy vehicle activity will increase markedly over the coming years.

The research is seeking to gain a better understanding of crashes involving heavy vehicles in an urban environment, the identification of factors that contribute to crash severity and occurrence, and ultimately the trialling and implementation of safety measures. The project has included the undertaking of a literature review, the identification and assessment of potential safety improvement options, which include intelligent transport systems (ITS) technologies, and consultation with a representative sample of key stakeholders. It has also involved site investigations of a representative sample of high heavy vehicle crash locations in urban areas, and the selection and trialling of suitably selected (new or innovative) treatments for improved heavy vehicle safety.

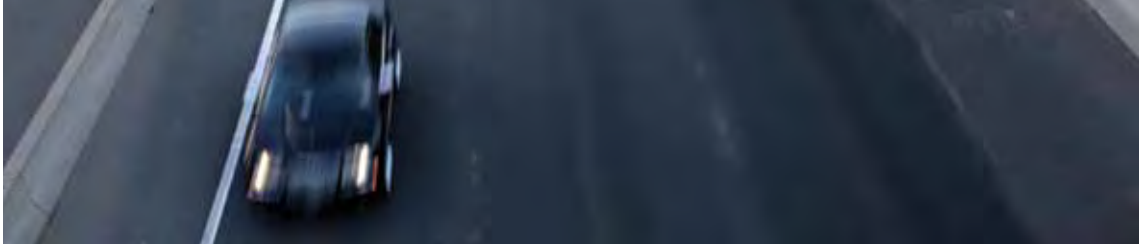


Photo: J. Best

Roadside advertising

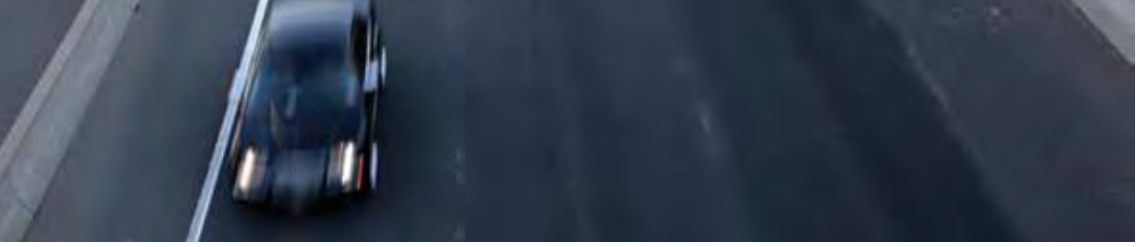
While it is recognised that inattentive driving is a contributor to highway crashes, criteria for the management of roadside advertising devices vary between jurisdictions. In a number of states, responsibility for the criteria resides with the state planning agency, while in others it is a road agency function. A number of state road agencies have sponsored projects to better inform themselves about the safety implications of outdoor advertising, which has resulted in variations in jurisdictional practice. Some of the guidelines are quantitative, while the others are qualitative. Given that the income derived from outdoor advertising can be significant, particularly on high-volume corridors, the guidelines tend to be 'played off' against each other by the outdoor advertising industry. In addition, a significant emerging safety issue is the use of digital display technology for outdoor advertising signs.

This project was designed to facilitate the harmonisation of agency criteria for the management of roadside advertising devices and promote improved and consistent practice by road agencies. Most importantly, it will assist road agencies to understand and address a significant emerging safety issue – the use of digital display technology for outdoor advertising signs.

The first three major milestones (literature review, documentation of practices, and assessment of human factors elements related to digital display technology) are essentially complete. The final milestone (development of guidance) is progressing well.

Operational impact of reduced speed limits

The effect of lowering speed limits on the road safety performance of road networks is well documented. However, the effect of either increasing or decreasing speed limits on other network and traffic performance indicators is less well understood. A previous Austroads project modelled the impact on traffic operational and environmental performance indicators of lower speed limits being applied to urban arterial roads. This project is seeking to identify the effect of changing



speed limits via traffic surveys on rural and urban arterial roads where a change in the speed limit is proposed.

Year one of this two-year project has seen the completion of a study method, trialling of suitable vehicle and traffic data collection technologies and invitation to road authorities to nominate suitable routes where speed limits will change. Journey travel and vehicle performance data has been collected on routes in NSW and Victoria under existing speed limit conditions. Year two will require a return to these sites to collect the same data under the changed speed limit conditions.

Selected outputs from the Road Safety Engineering research program in 2010/11

Publications available from Austroads publications website: www.onlinepublications.austroads.com.au

Innovative road safety measures to address fatigue: review of research and results from a treatment trial, Roberts, Rodwell, Harris (AP-R379/11)

Safe intersection approach treatments and safer speeds through intersections, McLean, Croft, Elazar, Roper (AP-R363/10)

The road safety consequences of changing travel modes, Cairney (AP-R361/10)

Other outputs

Methods to achieve overall reductions in operating speeds in rural areas: interim report, Turner, Pyta, Eady, Zhang (Austroads Internal Report IR-193/11)

National risk assessment model: program development and trials: interim report, Turner, Jurewicz, Cairney, Zivanovic, Turner (Austroads Internal Report IR-194/11)

Road Safety Audit and Engineering Toolkit: site maintenance, Steinmetz, Jurewicz (Austroads Internal Report IR-189/10)

Road Safety Audit Toolkit: further development, Steinmetz (Austroads Internal Report IR-188/10)

Photo: W. Hore-Lacy

Austroads

promoting improved road transport outcomes

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