



THE WESTERN AUSTRALIAN ROAD RESEARCH INNOVATION PROGRAM

2019 - 2021
PROGRAM HIGHLIGHTS



ABOUT THE PROGRAM

The Western Australian Road Research and Innovation Program (WARRIP) strategically targets research and development, technology transfer and capability development by providing a stronger commitment to innovative practices that will achieve significant savings for Main Roads WA in total road expenditure and a higher rate of return through targeted research.

A JOINT PARTNERSHIP BETWEEN:



VISION: Delivering engineering excellence with value-for-money outcomes through the conduct of leading road technology research that welcomes innovation and private sector participation. Striving to drive more efficient road management practices through the implementation of fit-for-purpose solutions.



COST SAVING

Deliver savings through improved, value-for-money investment decisions, maximising the benefits of every transport dollar.



COLLABORATION

Working together with industry, universities and government bodies to maintain and enhance technical capability within the State and achieve better outcomes.



DEVELOPMENT

Develop the capabilities of staff and disseminate learnings to regions in a growing State.



IMPLEMENTATION

Implement innovation through facilitating trials and establish research tools and technical support documentation.

ACKNOWLEDGEMENT OF COUNTRY

Main Roads Western Australia and the Australian Road Research Board acknowledge the traditional custodians throughout Western Australia and their continuing connect to the land, water and community. We pay our respects to all members of these Aboriginal communities, their cultures and to Elders past and present and to their leaders in the future.

PROGRAM SNAPSHOT

AS OF 2021, THE WARRIP'S RESEARCH OUTCOMES HAVE RETURNED AN ESTIMATED DIRECT AGENCY COST SAVINGS OF BETWEEN \$43.7 - \$75.5 MILLION AGAINST PROGRAM COSTS TOTALING \$5.7 MILLION.

45

RESEARCH TOPICS INVESTIGATED

64

TOTAL PROJECTS

54

PROJECTS COMPLETED



Main Roads WA has the largest geographically dispersed road network in the world.

COVERING
2.5M KM²

18,600 KM
STATE ROAD NETWORK

\$49B
ROAD NETWORK ASSET VALUE

YEARS ACTIVE

6

ACHIEVED BCR
(2019-2021)

>8.2

55%

RECOMMENDATIONS
IMPLEMENTED

PROJECT DELIVERY

82%
On time

90%
On budget

75%
To required quality

MILESTONES DELIVERED

127



2 UNIVERSITY
COLLABORATIONS



4 INDUSTRY
PARTNERSHIPS



3 JOINT RESEARCH
PROJECTS

19

PROJECTS THAT ADDRESS INNOVATIONS THAT OTHERWISE WOULD HAVE BEEN INTRODUCED IN WA OR MAIN ROADS WITHOUT THE WARRIP

PARTNERSHIP

The partnership between Main Roads WA and the Australian Road Research Board aligns the strategic goals of both organisations and recognises Main Roads WA's desire to focus on road infrastructure-related research through the provision of secured, multi-year committed funding.

PRIMARY PARTNERS:



THE GOVERNMENT OF WESTERN AUSTRALIA AND MAIN ROADS WESTERN AUSTRALIA

Main Roads WA is the state's road agency charged with moving and connecting people, places, goods and services safely, efficiently and effectively across Western Australia. Responsible for planning, building, maintaining and operating Western Australia's State Road Network, their goal is to keep WA moving and aspire to provide world class outcomes through the implementation and management of safe, reliable and sustainable road-based transport systems.



THE AUSTRALIAN ROAD RESEARCH BOARD (ARRB)

ARRB is a not-for-profit organisation whose members are the road agencies of the Australian states and territories, the New Zealand Transport Agency, the Australian Government and the Australian Local Government Association. ARRB was founded in 1960 and is the source of independent expert transport knowledge, advising key decision makers on our nation's most important challenges. ARRB has a strong heritage of supporting and delivering high quality applied research for Australian and New Zealand state road agency members and for the community.

PARTNERSHIP BOARD

The Partnership Agreement Board between Main Roads WA and ARRB oversees the relationship and governance of the program, sets the strategic direction and agrees on the governance arrangements.

DOUGLAS MORGAN, MANAGING DIRECTOR, MAIN ROADS WA



"Main Roads is committed to embracing innovations that provide better safety, reliability and sustainability outcomes for users of the WA road transport system. We have partnered with ARRB to establish the WARRIP, a cooperative research initiative focused on improving practices and tackling challenges in delivering and maintaining WA's vast road network. Main Roads encourages collaboration with relevant discipline specialists to develop implementable solutions. Creation and advancement of local technical expertise, in addition to building and strengthening relationships, are key objectives for the program. It's our expectation that the WARRIP will continue to support Main Roads in delivering better social, environmental and economic outcomes into the future."

MICHAEL CALTABIANO, CHIEF EXECUTIVE OFFICER, ARRB

"As the roads sector transforms into an integrated transport and mobility sector the WARRIP will remain central to the discovery of new sustainable materials, processes and technologies to support this journey. This transformation requires the skilled application of great engineering talent that is a cornerstone of the wonderful partnership between Main Roads WA and ARRB. The development of new knowledge in the areas of Sustainability and Material Performance, Safer Smarter Infrastructure, Asset Performance and Mobility Futures has crystallised the opportunity into practical outcome focused work leading to real change in the way in which the biggest State Asset in WA – the road system, is designed, built, measured and performs."



AGREEMENT MANAGERS

Implementation of the WARRIP is undertaken by Agreement Managers from both partners who execute the strategic plan by approving the rolling development of a multi-year program of works, monitor the delivery of results and manage the general administration of the program.

JONATHON GRIFFIN, MAIN ROADS WA



"The focus on collaboration has been instrumental in building relationships, optimising solutions and advancing business-as-usual. ARRB provides nationally and internationally recognised expertise and Main Roads contributes history of practice and an appreciation of the local environment. Together with partners in Local Government, Industry and Academia, the WARRIP is delivering practical solutions that are improving the design, construction, maintenance and management of road infrastructure in WA."

NATALIE LOCKWOOD, ARRB

"WARRIP provides an amazing opportunity for ARRB and Main Roads to collaborate on the problems and opportunities of today and tomorrow. It allows the greatest minds of our two organisations to ask the hardest questions and explore the most innovative solutions. The strong focus on implementation also ensures that our solutions are practical and cost-effective. I look forward to our continued collaborations with local government, industry and academia in this exciting Program."



AREAS OF RESEARCH

Since 2015, the partnership between Main Roads WA and the ARRB aligns the strategic goals of both organisations and recognises Main Roads' desire to focus on road infrastructure-related research.



PAVEMENTS & SURFACINGS

- » Best practice use of existing, new or innovative pavement materials.
- » Rehabilitation of existing pavements and pavement maintenance.
- » Spray seal surfacings including construction and materials.
- » Asphalt pavement design practices and treatments.



ROAD ASSET MANAGEMENT

- » Best practice asset management and improved decision making using traffic speed data.
- » Improving decision making through data collection and analytics.



STRUCTURES

- » Investigating innovative solutions that mitigate structural decay.
- » Improving operational lifespan of structural assets.
- » Increasing value extraction from road structures.

WARRIP PROJECTS



Characterisation of Asphalt Mixes Incorporating Polymer Modified Binder



Review of Moisture Impacts on Asphalt Pavement Performance



Investigating the Suitability of WA Mine Waste for Infrastructure Related Projects



Evaluate the Digestion of Crumb Rubber in Road Grade Bitumen



Advanced Epoxy Timber Pile Repair



Gap Analysis of Main Roads ROSMA Database and Road Trauma Treatment Guidelines



Impact of Large Stone Fractions on the CBR of Granular Pavement Materials



Management of Perth's Smart Freeways Long Lever Cantilever Sign Structures



Investigating the use of Recycled Plastics in Future Sustainable Road Infrastructure



Evaluate the Effectiveness and Cost Benefit of Preventative Maintenance Treatments



Heavy Vehicle Impacts Cost Estimation Process and Fund Allocations



Asset Preservation Case Study for Development and Training for Practitioners



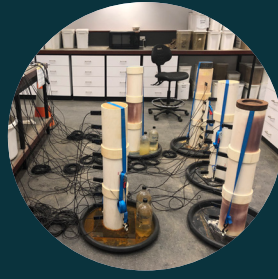
Investigating the use of Recycled Materials in Granular Support Layers in WA



Intelligent Compaction Control (ICC) - Field Trial Methodology and Trials



Sustainability Assessment Tool for Innovative Pavements



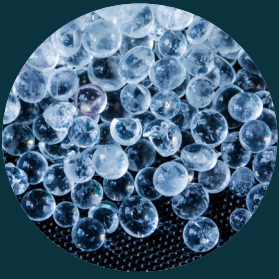
Development of a Standard Test Method for Measuring Capillary Rise of Non-Cohesive Soils



Best Practice Non-Destructive Quality Assurance Testing for Asphalt



Investigating the use of Reclaimed Asphalt Pavement from Asphalt Containing CRM Binder



Evaluation and Characterisation of Nanosilica-Modified Asphalt Materials



Optimising Laser Profilometer Data to Report Rut Depth, Roughness and Surface Texture



Development of a Bond Strength Test for Assessing Delamination Potential of Asphalt Pavements



Review of Light-Emitting Lane Demarcation Technologies



Review of Innovative Pavement Technologies

As of 2021, the WARRIP has conducted 64 research projects across three disciplines areas tackling 45 infrastructure related questions and concerns.

**image credits located on pg. 25*



Use of Drone Analytics at Roundabouts for Safety and Design Considerations



Communicating the Benefits of Revised Thin Asphalt Design Method



High Modulus Asphalt (EME2)



Communicating Sustainable Maintenance Funding Levels to Decision Makers and the Community



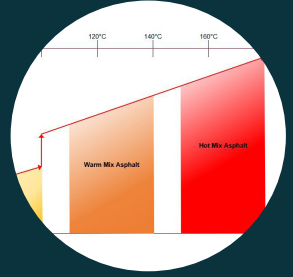
Evaluation of Traffic Speed Deflectometer (TSD) for Main Roads WA



Investigation of Asphalt Pavement Temperatures in WA



WA Rehabilitation Supplement to Austroads Part 5



Development of Specification and Technical Guidelines for Warm Mix Asphalt



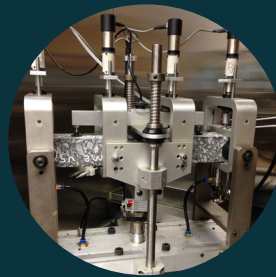
Implementing the Increased use of Reclaimed Asphalt Pavement (RAP)



Hydrated Cement Treated Crushed Rock - Base Trial Sections



Cost Effective Pavement Thickness Design



Asphalt Fatigue at Elevated Temperatures



Review of Stone Mastic Asphalt in WA



Dynamic Loading Effects of Heavy Vehicles on Pavement Performance



Investigations of the Tonkin and Reid Hwy Trial Sections



Transfer of Crumb Rubber Modified (CRM) Bitumen Technology to WA



Engineering Road Note 9 (ERN9)



Improved Decision Making and Works Program Development with Continuous Network Strength and Condition Data



Ground Instrumentation for Traffic Speed Deflectometer (TSD)



Optimised Australian National Risk Assessment Model using TSD Data



Review of Density Compliance Systems for Subgrade and Embankment Construction



Towards Best Practice in Management of Road Pavement Assets



Identifying Best Pavement Practice for Major Projects

BENEFITS OF THE WARRIP

The WARRIP endeavours to investigate and implement practices which will achieve a savings for Main Roads WA in terms of total road expenditure and deliver a higher rate of return. The long-term benefit-cost ratio (BCR) of six times (6.0) the program's investment was set for the program as an initial target.

The benefits of the WARRIP are assessed using a 3-level approach (qualitative, quantitative and a monetised level) to calculate both the direct agency cost savings to Main Roads WA and savings to the wider WA community, industry and economy. Each project is first assessed at the qualitative level to identify key benefits which undergo further assessment at the quantitative and monetised level. The calculated benefits are then compared to the total cost of the program to produce the BCR.

WARRIP's BCR is at least 8.2, above the target of 6.0.

The following table showcases projects which address innovation and have been introduced to WA and Main Roads through the WARRIP:

WARRIP STAGE	PROJECT YEAR	PROJECT NAME
Stage 1	2016	High Modulus Asphalt (EME2)
		Review of Innovative Technologies
		Investigation of In-Pavement Temperature Profiles for FDA Pavements in WA
	2017	Asphalt Fatigue at Elevated Temperatures
		Dynamic Load Effects of Heavy Vehicles on Pavement Performance
		Use of Main Roads WA Corporate Data for Road Safety Risk Data Sets
	2018	Ground Instrumentation for TSD
		Review of Density Compliance Systems for Subgrade and Embankment Construction
		Evaluation of Nanotechnology Benefits in Asphalt
		Development of a Test Method for Testing Capillary Rise on Non-cohesive Soils
	2019	Review of Applicable Bond Strength Tests for Assessing Asphalt Delamination Potential
		Review of Light Emitting Lane Demarcation Technologies
		WA Rehabilitation Supplement Part 5
		Using Laser Profilometer Data to Report Rut Depth, Roughness and Surface Texture
		Development of a Standard Test Method for Capillary Rise of Non-cohesive Soils
Stage 2	2020	WA Rehabilitation Manual or Supplement to Austroads Part 5
		Optimising the Use of Recycled Materials in Granular Support Layers in WA
	2021	Investigating the Use of Recycled and Reclaimed Plastic in Safe, Sustainable Future Road Infrastructure
		Communicating sustainable maintenance funding levels to decision makers and the community

ASSESSED BENEFITS

DIRECT AGENCY BENEFITS FOR MAIN ROADS WA



- Examples include:
- Construction cost savings
 - Maintenance/rehabilitation savings
 - Material cost savings
 - Data collection/analysis efficiency
 - Whole-of-life savings

LOCAL ROAD NETWORK



- Examples include:
- Benefits from the adoption of Main Roads WA guidelines
 - Potential cost saving categories similar to Direct Agency Benefits.

INDUSTRY (CONTRACTORS/DIRECT SUPPLIERS ETC.)



- Examples include:
- Guidance (i.e. consistent design approach).
 - Material cost savings
 - Process improvements
 - Reduced landfill costs
 - Reduced storage cost

ROAD USERS



- Examples include:
- Travel time savings
 - Road safety improvements
 - Smoother road surfaces
 - Decreased injuries
 - Reduced vehicle operating costs

WIDER COMMUNITY



- Examples include:
- Improved accessibility
 - Road noise reduction
 - Efficient use of tax payer funds

ENVIRONMENTAL



- Examples include:
- Reduction of greenhouse gas emissions and air pollutants
 - Waste reduction

CAPACITY BUILDING & HUMAN RESOURCE DEVELOPMENT



- Examples include:
- Strengthening of research relationships
 - Retention of expert staff
 - Provision of technical documentation

FOCUSSED RESEARCH DIRECTION



- Examples include:
- Future potential savings based on greater body of knowledge in key road transport research topics

PROMOTION OF MAIN ROADS WA AND ARRB



- Examples include:
- Presenting or publishing research outcomes (e.g. journals, conferences) which lead to future work and innovation
 - Undertaking joint initiatives with Austroads and NACoE



WARRIP PROJECT: TRANSFER OF CRUMB RUBBER MODIFIED (CRM) BINDER TECHNOLOGY TO WESTERN AUSTRALIA

TECHNICAL AREA: PAVEMENT AND SURFACINGS

YEARS: 2016 - 2020

The practice of recycling end-of-life tyres for use in road construction has been in place for over 30 years in WA. Crumb rubber modified (CRM) binder technology when incorporated in asphalt and sprayed bituminous seals provides improved pavement performance, reduced landfill waste and preservation of natural resources.

Over 3 stages, the development, implementation and characterisation of a CRM Open Graded Asphalt (OGA) and two CRM Gap Graded Asphalt (GGA) mixes for use in WA was realised through the WARRIP. Together with industry partner Fulton Hogan, these CRM asphalt mixes underwent manufacture and construction trials to evaluate the practicability of the mixes. Laboratory performance testing indicated that both mixes will perform well in the field, providing equal or greater durability when compared to the typical polymer modified binder mixes.

The results informed the development of draft Main Roads WA specifications for CRM binder in both OGA and GGA mixes, facilitating its use as a standard product in WA. On 16 November 2020, Main Roads WA published the CRM OGA specification. The draft specification for the CRM GGA mix is being finalised with publication anticipated in mid-2021.



Image descriptions:

Left: Placement of crumb rubber modified (CRM) open graded asphalt (OGA).

Top Right: Surface texture of a CRM OGA compacted section.

Bottom Right: Straight edge testing of transverse joint for CRM-OGA.

RESEARCH OUTCOMES

The WARRIP can measure its successes not on the statistics of achievements as contained hereafter, but on its ability to disseminate the findings for ease of adoption and implementation.



REDUCED EMISSIONS

A key sustainability consideration is reducing the impact of pavement construction and maintenance by reducing the emissions during these actions.

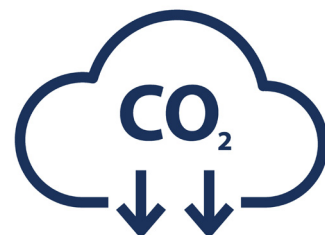
A key project delivering lower emissions is **crumb rubber modified asphalt**. Crumb rubber modified asphalt has been successfully trialled with our industry partner, Fulton Hogan, in open grade asphalt, opening the door to increasing the use of old rubber tyres previously sent to landfill. Not only does this technology have environmental benefits but it also improves the performance of pavements offering increased durability and crack resistance.

The **sustainability assessment tool (SAT)** is one of the collaborative projects with NACoE and has produced a web-based tool designed to compare the life cycle costs and environmental impact of pavement technologies for specific projects. The focus of the SAT is to assess the cost and environmental impact of the use of innovative materials in pavements, such as crumb rubber, recycled plastics or recycled glass with the aim of selecting a material which demonstrates a combination of cost savings and reduced emissions over all pavement life cycle phases including old pavement removal, construction (including material production), maintenance, end-of-life, and materials haulage/transport which occurs across multiple life cycle phases.

In terms of environmental impact, the SAT considers greenhouse gas emissions (in CO₂-equivalents) as well as energy and fuel/electricity usage, airborne pollutants, and water usage. EnviroPoints (according to the Infrastructure Sustainability Council of Australia, ISCA) is included as well. It is anticipated that once this tool is implemented by Main Roads and industry to assist with decision making, material selection, emissions, pollutants, energy and water use will be minimised while simultaneously ensuring cost effective solutions.



Shredded tyres (Drpixel - stock.adobe.com)

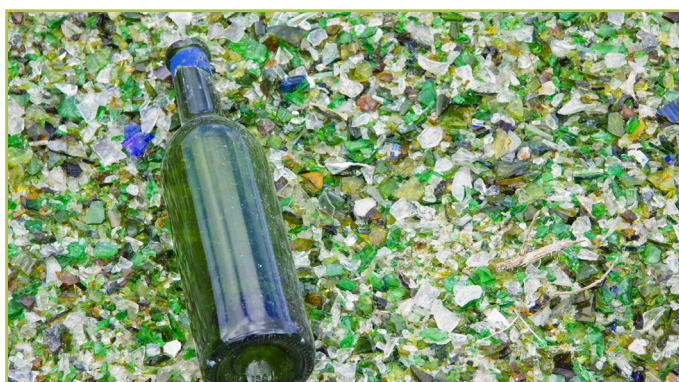




RECYCLED MATERIALS

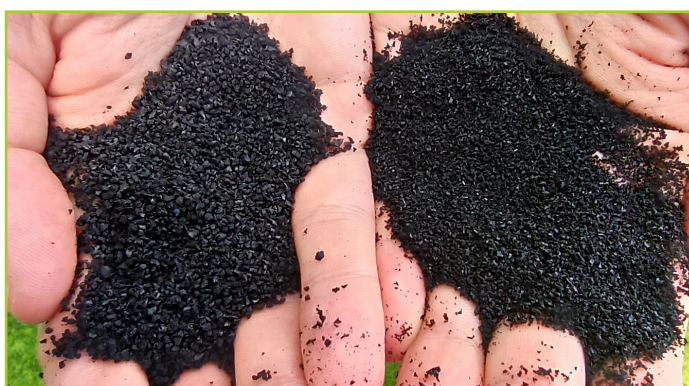
The WARRIP continues to investigate innovative and alternative solutions for implementing recycled materials within pavements and road infrastructure. Using recycled materials not only reduces the amount of virgin materials required, but it also diverts waste products away from landfill for a higher value use, and in some instances can improve pavement performance.

Optimising the use of recycled materials for granular support layers in WA evaluated the waste streams and markets (urban/regional) for recycled crushed glass and crusher dust (aka waste quarry fines). The analysis compared costs, environmental impact and identified alternative usages for these materials (e.g. drainage and bedding fill). Main Roads WA specifications were reviewed along with associated design and procurement systems to facilitate the use of these products as alternatives to virgin materials and provided an updated design guidance that permits the use of these recycled materials in the appropriate circumstances. Once implemented these measures are anticipated to reduce the amount of recycled glass that is sent to landfill annually in WA.



Recycled crushed glass (pjhpix - stock.adobe.com)

The use of recycled and reclaimed plastics in safe, sustainable future road infrastructure is the second collaborative project with NACoE. It has investigated the domestic and international utilisation of recycled plastics in road/transport infrastructure to identify potential areas for using this material in WA and Qld. This first included an evaluation of the economics and viability of options within the plastic waste industries of both states. Next, strategies for selecting appropriate sources, types and groups of recycled plastic that maximise social impact, minimise the environmental footprint and maximises the performance of the receiving road construction products were developed.



Crumbed rubber samples

Continued investigation into the use of crumb rubber for modifying bituminous binders was also undertaken by the WARRIP. A new project aimed to understand the fundamentals of **crumb rubber digestion** upon mixing with a bituminous binder; to provide insight into optimised production, storage, transport, and incorporation of the crumb-rubber into bituminous binders. Through exploring different sources of waste rubber (e.g. conveyor belts vs. passenger tyres) and the effect of specific variables (e.g. crumb rubber size, digestion temperature, digestion time) on the final rheological properties of the modified binder were the project objectives. This greater understanding of crumb-rubber digestion

and resulting rheological properties will not only enable further development of Main Roads Specifications 516 and 517, it will ensure the quality of CRM binders used on WA roads and maximise performance benefits.

WARRIP

Image descriptions:

Top Left: Pressure cleaned timber pile prepared for repair.

Top Right: Mixing the epoxy solutions.

Bottom Right: Prepared timber pile receiving the epoxy mixture.

Bottom Left: Cross-section of a test pile demonstrating infiltration of epoxy solution.



WARRIP PROJECT: EPOXY TIMBER PILE REPAIR

TECHNICAL AREA: STRUCTURES

YEARS: 2020 +

The Western Australian road network still contains many timber bridges comprising Jarrah and Wandoo piles that have been in operation for more than 60 years.

Despite their age, these structures are typically sound apart from evidence of localised decay such as splitting, segmenting, loss of diameter, fin, and internal piping at the waterline and/or ground surface.

Over the past 20 years, Main Roads has successfully used epoxy fill/injection solutions as a semi-structural solution to mitigate localised deterioration. Based on this work, WARRIP has identified a potential value opportunity to explore further applications in the use of these epoxies as structural solutions for timber piles, specifically the prevalent “necking” problems.

This project's objectives are to develop an open-source, commercially available and fit-for-purpose design and rehabilitation solution to extend the service life from these existing timber bridges.







TIME SAVINGS

Updating test methods to include new technology results in time savings.

The development of a Main Roads test method for **bond strength** was investigated by the WARRIP. This test will be able to predict pavement performance at the asphalt layer interface and reduce time required for repairs on inadequately bonded pavements.

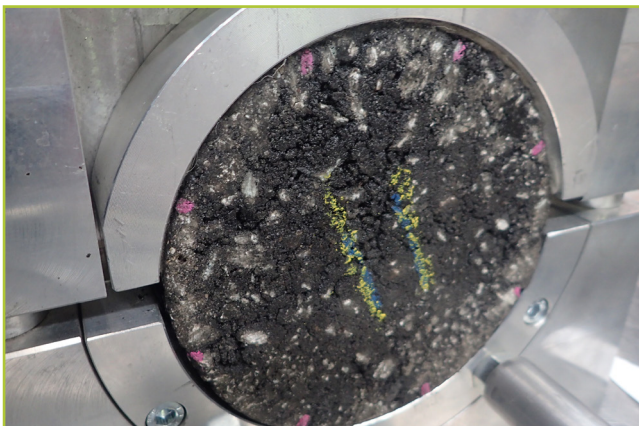


Application of an asphalt bond agent on a test pad.

Research outcomes which have also provided time savings benefits and solutions have focused on simple maintenance treatments which provide ongoing performance and are quick and easy to implement.

The evaluation of the effectiveness and cost benefit of preventative maintenance treatments for asphalt pavements is a prime example of these types of time saving solutions. By implementing these preventive maintenance treatments which are typically easily applied in a short amount of time with limited surface preparation or construction plant, the more intricate periodic full surface replacement can be reduced throughout the pavement life cycle.

Similarly, the use of **advanced epoxy** products in the maintenance of existing timber piles is another example of time saving maintenance treatments. The injection of the epoxy into the piles is quick and, in most cases, does not require specialist equipment or training. The epoxy injection restores the structural capacity of the timber pile reducing the need for full replacement which can be time consuming and expensive especially in regional areas where these timber structures are most prevalent.



Asphalt core in the Leutner apparatus to test the bond strength.



Pouring epoxy into an existing timber pile.



MATERIAL SAVINGS

Savings on materials and providing transparency around material related costs continue to be a key focus of the WARRIP. The initial focus in this area considered pavement thickness and the reduction thereof as a means of saving on material.

Recent projects are investigating fit-for-purpose material usage to encourage and facilitate the acceptance of natural materials especially in the regions. Together with the *sustainability assessment tool (SAT)* that allows the savings from utilising different materials to be quantified to aid in choosing the most cost-effective material for the job, *evaluating the influence of large stone fractions on the bearing strength of granular materials* is a project aimed at developing a revised laboratory test method to account for the oversize fraction (>19 mm) of a granular pavement material when undertaking the California Bearing Ratio (CBR) test. This will allow representative bearing strength characterisation for use in pavement designs, encouraging wider use of locally sourced regional materials which are observed to perform well in-service but do not necessarily meet the CBR criteria due to the unrepresentative nature of the test due to the removal of a large amount of material > 19mm in size.

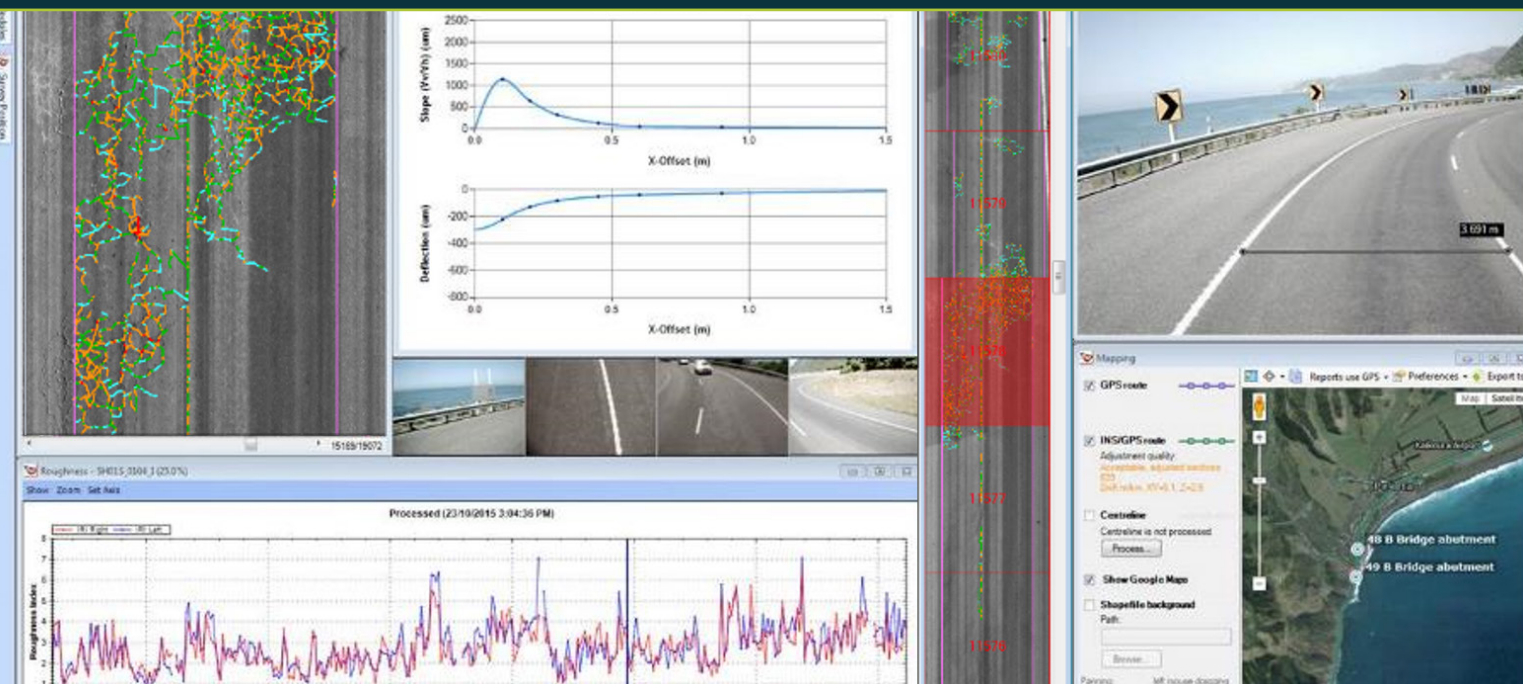
Discussed previously as a way of quantifying and reducing emissions, the *SAT* also allows material cost savings to be optimised by providing a mechanism of comparing different innovative materials including recycled materials or other new technologies.

As part of ensuring Main Roads ERN9 is current and reflect best practice regular reviews and updates are undertaken. WARRIP has been continuing these reviews through a project comparing the different *thin asphalt design methods* proposed by past WARRIP projects to ensure the most applicable and beneficial method is ultimately included in ERN9.

Finally, gathering data on *asphalt temperature* across the diverse climatic conditions in WA has been a long-term focus of WARRIP and has continued. Understanding the climatic conditions pavements are exposed to will inform designs and provide thinner solutions with better understanding of the relationship between temperature and asphalt fatigue in-service.



Reclaimed asphalt from an existing road (wuttichok - stock.adobe.com).



WARRIP PROJECT: IMPROVING DECISION MAKING AND WORKS PROGRAM DEVELOPMENT WITH CONTINUOUS NETWORK STRENGTH AND CONDITION DATA (IDM)

TECHNICAL AREA: ROAD ASSET MANAGEMENT

YEARS: 2018 - 2021

The '*Improving decision making and works program development with continuous network strength and condition data*' (referred to as IDM) project explores how pavement strength data collected using the Traffic Speed Deflectometer (TSD) can be best used in road maintenance decision making.

The under estimation of Main Roads WA's road deterioration (RD) model prompted a revision to better account for maintenance inputs to the network that masked the underlying rate of deterioration. However, the model's simple regression-based analysis combined with limited explanatory parameters that excludes critical parameters related to traffic loading and structural attributes contributed to these poor results.

Using available TSD data (including maximum deflection, curvature, roughness, rutting and cracking parameters) for the whole state network to inform model improvements, a comprehensive RD model is being developed. Outputs from this model is anticipated to enhance Main Roads WA's ability to justify appropriate funding levels and allocate this across the network. Furthermore such an approach better addresses the effects of budget constraints and alternative strategies, including holding treatments, to manage the network in as optimal a condition as possible and maximise Main Roads WA's investment in traffic-speed data which is now available for the full network.

Image descriptions:

Top: Road demonstrating deterioration (S. Zemlyanskiy, Shutterstock.com)

Middle: ARRB's iPAVe survey vehicle (with TSD) that assesses road surface and sub-surface conditions at traffic speeds (ARRB, 2019).

Bottom: Various iPAVe data collection outputs (ARRB, 2019).



REDUCED USER COSTS

WA's geographical distribution means that the state maintained arterial road network is essential for connecting the industry and communities. Unexpected growth in localised industries such as mining and agriculture can result in a significant increase in heavy vehicle loading. This affects the performance of the road infrastructure often through rapid deterioration as these roads are not designed for the increased heavy vehicle loading. The project, *Heavy vehicle impacts cost estimation process and fund allocations* developed a viable and sustainable costing process in which to assess these heavy vehicle impacts across the state-controlled road network. Significant funding is required to maintain acceptable levels of service well in excess of the maintenance funds that have been allocated. This solution will ensure that Main Roads WA can effectively assess the funding requirements and optimise spending to maintain acceptable levels of service across the road network thus resulting in lower user costs as these roads can be maintained more effectively and to a higher standard. Improving the road and riding quality can result in numerous road user benefits such as less wear and tear on vehicles, less damage to goods in transit, reduced fuel use and most importantly improved travel time.



Mining industry heavy vehicles (shubas - stock.adobe.com)



SAFETY IMPROVEMENTS

WARRIP projects with safety benefits have shifted to focus on guideline updates and database reviews to ensure the selection of road safety treatments are optimised.

The project *Crash reduction factors review, and update (ROSMA database / Road Trauma Treatment Guidelines)* is ensuring that the Main Roads WA road safety management system (ROSMA) is current and that the road trauma treatment guidelines reflect national and international best practice. This includes using crash reduction factors (CRFs) to inform practitioners as to the relative performance of various road safety treatments. The update and application of these resources will enable Main Roads to ensure the best road safety outcomes based on available funding thus optimising the safety benefit of the WA network.



CONSTRUCTION COST SAVINGS

Significant indirect savings can be achieved by improving the efficiency of the methods used to construct roads, especially in light of the vast network maintained across the whole of Western Australia.

As previously mentioned, the project investigating *the optimised use of recycled materials in granular support layers* has demonstrated the potential for decreased construction costs when recycled materials such as crushed glass are utilised in place of conventional natural sand material. This is especially relevant for projects situated in areas where the capillary rise of groundwater into the pavement can be problematic. Using recycled crushed glass has the potential to reduce earthworks through a reduction of thickness of the support layer due to the capillary properties of crushed recycled glass when compared to natural sand.

Another project which is *evaluating the effectiveness and cost benefit of preventative maintenance treatments for asphalt pavements* also has the potential to decrease construction costs over the in-service life of an asphalt pavement by implementing surfacing rejuvenation treatments to prolong surfacing life. These treatments are easy to apply and have the potential to decrease the number of full surfacing removals and reseals over a pavement life which require much more intensive construction processes.

Similarly, the use of *epoxy to repair timber piles* is evaluating the effectiveness of repairing aged timber piles rather than replacing them or encasing them with concrete. Approximately 40% of the Main Roads bridge stock are timber structures and therefore this project has the potential to reduce construction activities by providing an easy to apply maintenance treatment option as an alternative to full replacement.



Local bridge with timber piles.

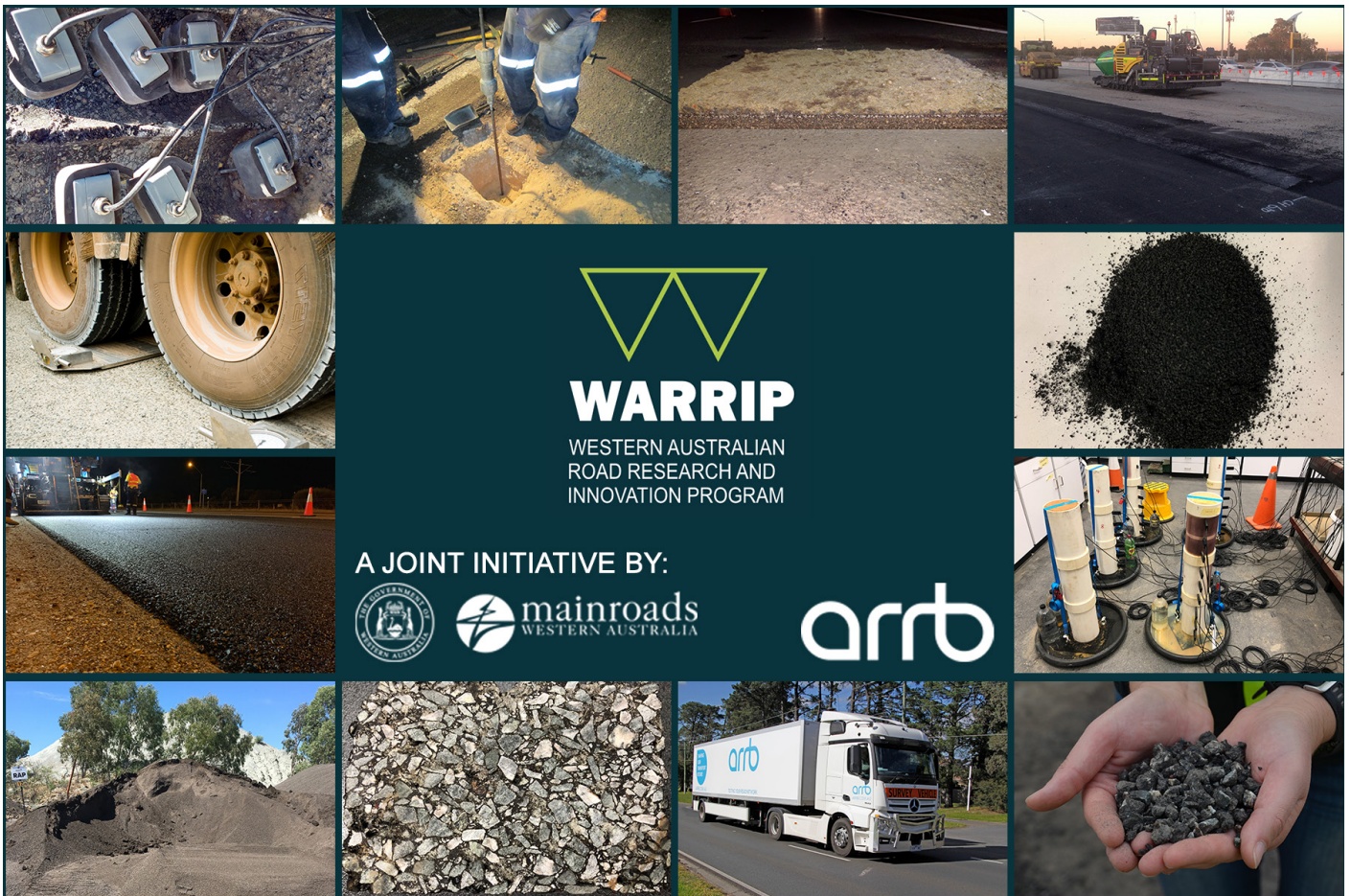


Glass waste in recycling facility (Belish - stock.adobe.com)

ACHIEVEMENTS

Main Roads WA and the ARRB were recognised by the Australian Flexible Pavement Association (AfPA) for the innovative research work conducted within the WARRIP program. The WARRIP won the 2020 Western Australian State and National awards for Innovation.

2020 STATE (WESTERN AUSTRALIA) & 2020 NATIONAL WINNERS OF THE INNOVATION AWARD



WARRIP

WESTERN AUSTRALIAN
ROAD RESEARCH AND
INNOVATION PROGRAM

A JOINT INITIATIVE BY:

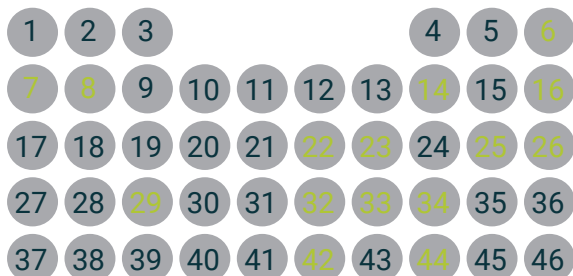


ACKNOWLEDGMENTS

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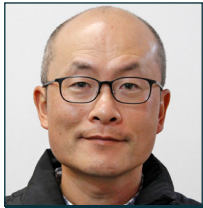
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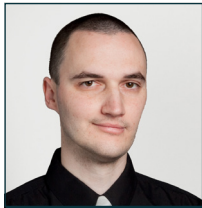
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M. MOFFATT



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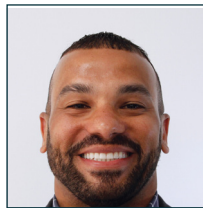
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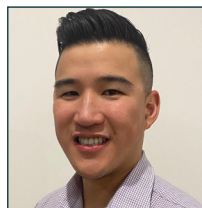
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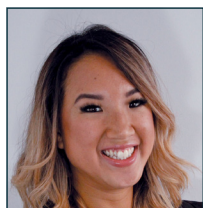
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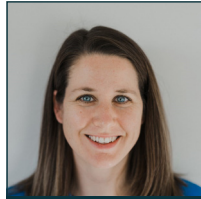
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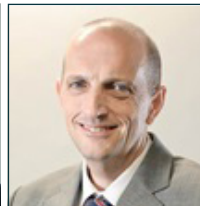
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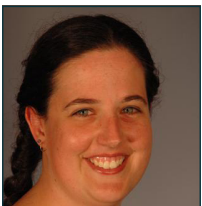
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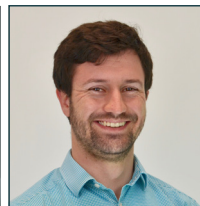
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