THE BENEFITS OF SURFACING ROADS WITH TYRE DERIVED CRUMB RUBBER

FINDINGS AND FACTS

CRUMB RUBBER: DURABLE, FLEXIBLE AND RECYCLABLE

FIRST REPORT
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TyreStewardship AUSTRALIA

Australian Government Accredited Product Stewardship Scheme

Crumb Rubber in road surfacing applications

This fact sheet provides a snapshot of the initiatives and the activities of Tyre Stewardship Australia (TSA) in relation to use of tyre derived Crumb Rubber in road surfacing applications. It also provides attributes, statistics, linkages and references to the various projects funded by TSA on the use of Crumb Rubber Modified Bitumen and Asphalt in road surfacing applications.

This document can also be accessed on our website: Click here

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TSA's purpose is to drive sustainable outcomes for end-of-life tyres (EOLT).

Our vision is a circular economy for EOLT which contributes to a sustainable society.

Our mission is to collaboratively ensure the sustainable management, recycling and productive use of EOLT.

Crumb Rubber in road surfacing applications

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Crumb Rubber (CR), derived from end-of-life tyres, has been utilised in road surfacing applications since 1975, with its first use in Victoria. Progressively, CR was then used in NSW and Western Australia. Recently the uptake has spread nation-wide, while also increasing the types of road surfacing applications that it can be utilised in.

Since its inception, Tyre Stewardship Australia (TSA) has played an important part in better understanding the sustainability and performance value contributed by the use crumb rubber. Various projects supported by TSA in creating demand by overcoming barriers, demonstrating benefits and enabling supply have been instrumental in this regard.

Create demand

- Research & Development into use and benefit
- Specification alteration and creation

Demonstrate benefit

- State authorities: Dept of Transport VIC, Transport and Main Roads QLD, Main Roads WA
- Local Government: Logan City Council, City of Mitcham

Enable supply

- Infrastructure procurement

Advantages of Crumb Rubber when compared to neat Bitumen

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- Elimination of waste, supports recycling and sustainability principles and improves the environment from less landfill.
- Higher resistance to deformation at increased road temperature, reduced degree of rutting, improves driving comforts even on higher axle loads.
- Crumb rubber bitumen has enhanced engineering properties
- Improved adhesion and bonding with aggregates, less windscreen damage and improves safety.
- Higher softening point, high flow resistance and higher impact resistance, takes heavy vehicular traffic.
- Increased viscosity avoids bitumen softening and flushing onto the surface of the sprayed seal.
- Improved skid resistance, better road grip and smoother vehicle break application, which reduces chances of accident.
- Higher elongation and tensile strength, increases elasticity. Reduced thermal sensitivity, which avoids all types of cracks under stress. Excellent ability to resist reflection cracking.
- Anti-stripping properties. High resistance to moisture/water absorption hence reduction to damage to roads during rains.
- Improved durability through the ability to use higher binder film thickness in sprayed seals.
- Cost effective binder relative to other polymer modified bitumen, crumb rubber pricing is at par or below that of bitumen.
- Longer road pavement life and lesser maintenance.

Demonstrated benefits of using Crumb Rubber Modified (CRM) binder

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3.1 Performance benefits of CRM binder in Sprayed Sealing

In sealing, CRM binder with high rubber content can be applied at a higher spray rate than bitumen without flushing (fattening-up of the road surface under traffic) occurring. The higher spray rate, in combination with the improved elastic, viscous and ductile properties of the binder, leads to benefits of CRM binder seals compared to seals with neat bitumen. These benefits include:

Service life is significantly increased

The higher spray rate and increased binder film thickness lead to later onset of oxidation cracking and stone loss. The carbon black component of the tyres working as an antioxidant is also believed to contribute to the superior longevity of CRM binder seals (Hoffmann & Potgieter 2007).

Durability of skid resistance is improved

The higher viscosity of the CRM binder leads to reduced stone embedment, and as a result, the seal maintains its texture depth (Hoffmann & Potgieter 2007).

Resistance against reflective cracking

There is superior resistance against reflective cracking (California Department of Transportation, 2003). CRM binder use originated from a desire to create a durable seal over cracks in asphalt roads. Its ability to arrest cracking is still one of the main reasons why CRM binder technology is used in sprayed seals. CRM binder seals are used as a maintenance action over cracked road surfaces. They are also used in specialised applications to insulate new pavement layers placed over existing pavements from cracks reflecting up from underlying layers. This application is known as a strain alleviating membrane interlayer. (Austroads 2013).

Improvement in waterproofing

Improvement in waterproofing of the road surface (Hoffmann & Potgieter 2007). One of the main functions of a sprayed seal is to keep water out of the pavement. The high spray rate of a CRM binder seal leads to a durable waterproof surface, which protects the underlying material.

3.2 Performance benefits of CRM binder in Asphalt

In asphalt, the use of CRM binder allows higher binder application rates in certain asphalt types without excessive drain down or bleeding due to the high viscosity of the binder (Lo Presti, 2013). The higher binder film thickness comes with considerable durability benefits. High binder film thicknesses retard oxidative aging, which is especially important in open grade (porous) asphalt (OGA) mixes.

In OGA mixes oxidation eventually leads to raveling of the material, which is the main mode of failure for such asphalt. In Gap Graded Asphalt (GGA) mixes, the high binder film thickness, in combination with the improved elastic properties of CRM binder, results in much improved resistance to reflective and fatigue cracking (California Department of Transportation 2003). This was also verified in laboratory tests on Australian mixes (Austroads Pavements Research Group 1999).

Accelerated pavement testing conducted by the University of California has shown that GGA CRM binder asphalt placed at half the thickness of conventional asphalt over concrete outperforms the conventional asphalt in terms of resistance to reflective cracking (Jones, Harvey & Monismith 2007). This has led the California Department of Transportation to implement the rule that for overlays over concrete, conventional dense-graded asphalt may be substituted with CRM binder gap graded asphalt at onehalf the intended dense-graded mix thickness (California Department of Transportation 2003). Note that this half- thickness rule is relevant to resistance to crack reflection only, it does not pertain to the asphalt design thickness required to protect underlying layers.

Long-term pavement performance monitoring in Arizona has shown that CRM binder GGA outperformed conventional* asphalt in terms of cracking, maintenance costs, ride quality and resistance and rutting (Way, Kaloush & Biligiri 2011). Other studies have found CRM binder asphalt to have rut resistance like conventional asphalt, although there are indications that CRM gap-graded asphalt may be more susceptible to rutting than conventional asphalt (Jones, Harvey & Monismith 2007). In Australia, the reported benefits of using CRM binder in asphalt mixes over standard bitumen are (Roads and Traffic Authority 1995):

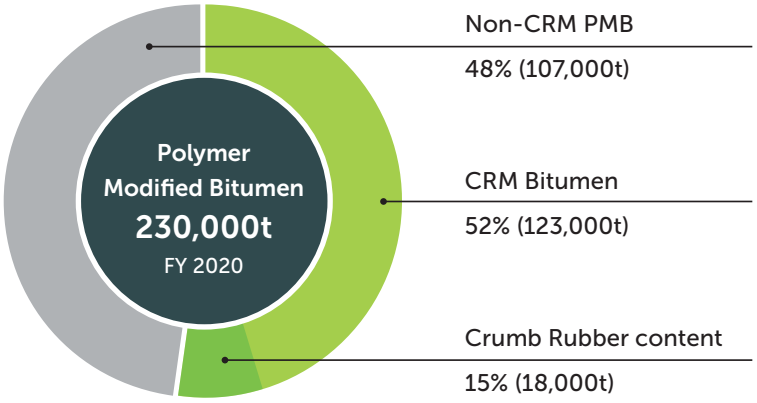
- Cost-effectiveness due to increased pavement life.
- Increased shear resistance including resistance to permanent deformation (rutting and shoving).
- Increased resistance to fatigue and reflective cracking.
- The use of an otherwise waste material.

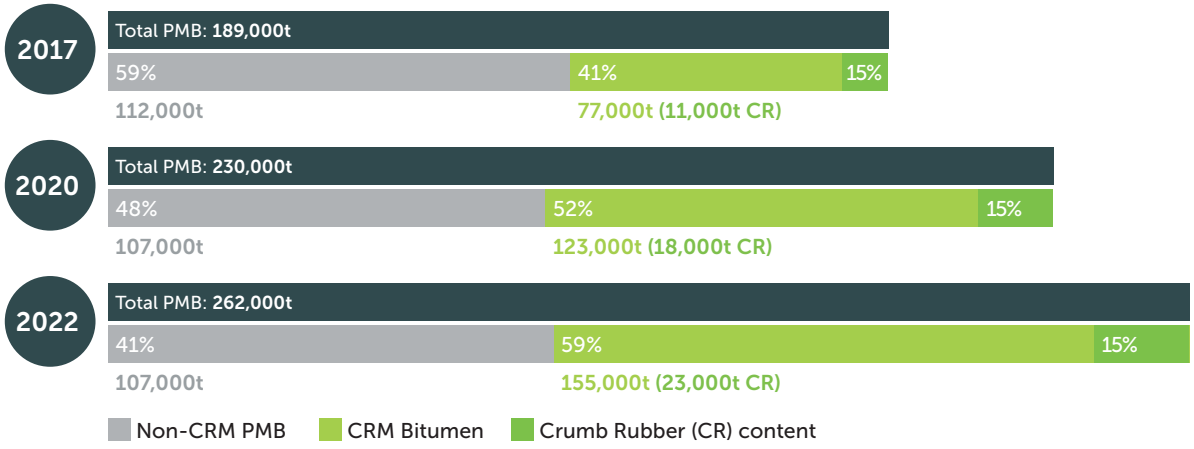
**Conventional asphalt refers to non polymer modified asphalt*

Statistics

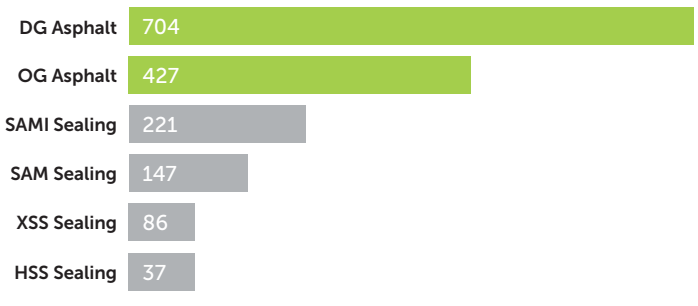
It is estimated that in 2020, 230,000 metric tonnes of Polymer Modified Bitumen (PMB) was used in Australia out of which Crumb Rubber Modified Bitumen was ~123,000 metric tonnes, 52% of the total modified bitumen market.

At an average of 15% crumb rubber content, this equates to 18,000 metric tonnes of crumb rubber or 3 million Equivalent Passenger Units (EPUs).





The volume of crumb rubber is likely to increase sharply due to the recent uptake of crumb rubber in asphalt application. This application uses the most amount of crumb rubber per Lane Kilometer constructed. In a positive development, most states in Australia are now moving towards the use of crumb rubber in various road surfacing applications.



EPUs per Lane Kilometer against treatment type

TSA initiatives

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TSA identified three areas of support needed to utilise crumb rubber in road surfacing applications. These are creating demand by overcoming barriers, demonstrating benefits and enabling supply.

5.1 Overcoming barriers and creating demand

Significant barriers have been overcome with specifications on crumb rubber modified bitumen in National (Austroads) and State Road Authorities specifications. Furthermore, TSA is actively working with academic and research institutions, state road authorities, statutory organisations and industry bodies in technology transfer, specification developments, performance assessments and training in the use of crumb rubber for road surfacing applications.

Jurisdiction	Relevant Guidelines, Codes and Specifications
International	ASTM D6114 / D6114M Standard Specification for Asphalt-Rubber Binder provides a standard approach to crumb rubber asphalt recommending a minimum 15% of rubber by weight of the total blend
National	Austroads Technical Specification ATS 3110 outlines the requirements for polymer modified binders, including crumb rubber, in BCRA and rubber modified spray seal applications.
NSW	Specification and DC3256 (22/06/2020) R118 Crumb Rubber Asphalt provides a dedicated specification for use of BCRA. Specification R107 Sprayed Bituminous Surfacing provides guidance for use of polymer modified binders including rubber modified spray seals.
Victoria	Section 421 Bitumen Crumb Rubber Asphalt and Section 522 (26/11/2019) Code of Practice RC500.01 set allowances and provisions for use of crumb rubber asphalt in Victoria. Bituminous Sprayed Surface Manual and Technical Note TN14 provide guidelines and requirements for rubber modified spray seals.
Queensland	Technical Specification MRTS 11 – Sprayed Bituminous Surfacing provides guidance and procedures for use of crumb rubber binder in spray seals Technical Specification MRTS18 - Polymer Modified Binder provides guidance and requirements for use of crumb rubber binder in BCRA
WA	MRWA Specification 516 - Crumb Rubber Open Graded Asphalt and Specification 511 – Materials for Bituminous Treatments provides some information related to crumb rubber treatments for bitumen products such as BCRA and rubber modified spray seals.
SA	RD-BP-S1 Supply of Bituminous Materials and Part R25 Supply of Bituminous Materials and Part R26 Guidelines provide guidance on the blending and application of crumb rubber binders for asphalt and spray seal.
NT	Standard Spec for Civil Maintenance V9.0 (FEB 2021), Spray Seal Surfacing – Selection of Binder Type and Standard Specification for Roadworks contain some requirements and details regarding use of crumb rubber binders.
Tasmania	Sprayed Bituminous Surfacing and Guidance Notes for Bituminous Surfacing Specifications provide broad guidelines for road construction, including use of crumb rubber binders.
ACT	The following general specifications refer to crumb rubber: ACT Trunk Road Infrastructure Technical Specification No. 04 – Flexible Pavement

5.2 Demonstrating benefits

While there is already widespread use of crumb rubber in road surfacing applications, there are still applications where it has been necessary to demonstrate the benefits; a major one being in the application of hot mix asphalt. TSA has provided significant support to various collaborations with the road authorities, local government and industry in placement and monitoring of road surfacing demonstration projects. Projects supported to date have provided valuable learnings.

TSA Initiatives to promote benefits of CRM binder in Asphalt

Case Study: City of Mitcham (South Australia)

In partnership with Tyre Stewardship Australia, the City of Mitcham developed a crumb rubber asphalt mix for application in a local road test environment to demonstrate the improved crack resistance and longevity that could be achieved through the addition of waste tyres.

Asphalt mix type	Fatigue Cycles to failure	Moisture sensitivity Tensile strength ratio	Rutting Wheel tracking deflection
Conventional Asphalt (C320)	116,868	77%	7.5mm
Crumb Rubber GGA	498,805	87%	3.6mm

The results demonstrated outstanding properties with regards to **fatigue** failure through the addition of crumb rubber in the binder mix, with the CRM binder sample lasting close to 4 times longer than the C320 mix. The results are a good indicator that the CRM mix is more resilient to fatigue cracking in the field than a normal C320 mix and shows a significant increase in performance.

Moisture sensitivity testing is undertaken by comparing the loss of tensile strength of the asphalt after saturating the sample with water, with the CRM asphalt demonstrating better cohesion and aggregate bonding properties than the standard C320 mix and would be indicative of improved crack resistance and moisture performance over typical asphalt.

Predictions of the performance of an asphalt mix in the field with regards to **rutting** and repeated loading over time can be estimated using the wheel tracking test, where a set load is applied over the sample, which in this case was 10,000 times. The CRM mix produced significantly better results and it could be expected that excellent performance could be achieved in a local road setting, as can be seen in the table above. This shows that conventional AC14 C320 mix deflect more than twice as much as CRM mix.

5.3 Enabling supply

The use of crumb rubber involves either pre-blending the crumb rubber with bitumen at a centralised plant and then transporting to the jobsite or having the mixing equipment onsite for blending 'just in time'. This is designated as a "wet process". Alternatively, in asphalt applications the crumb rubber can be directly introduced during the manufacture of the hot mix, this is designated as a "dry process". In either case of the process, the blending or the introduction of the crumb rubber requires additional and sometimes specialised equipment to ensure better dispersion, thus providing a consistent quality outcome.

TSA has supported the enhancement and the expansion of the blending capacities by supporting industry partners in the set up of improved processes and procurement of specialised equipment.

Click here to see road projects funded by TSA:
https://www.tyrestewardship.org.au/handbooks/tsa-funded-projects-brochure/

5.4 Supply Chain

Click here to visit TSA's Source Recycled Page for a list of Crumb Rubber suppliers:

https://www.tyrestewardship.org.au/product/crumbrubber/

Links and references

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