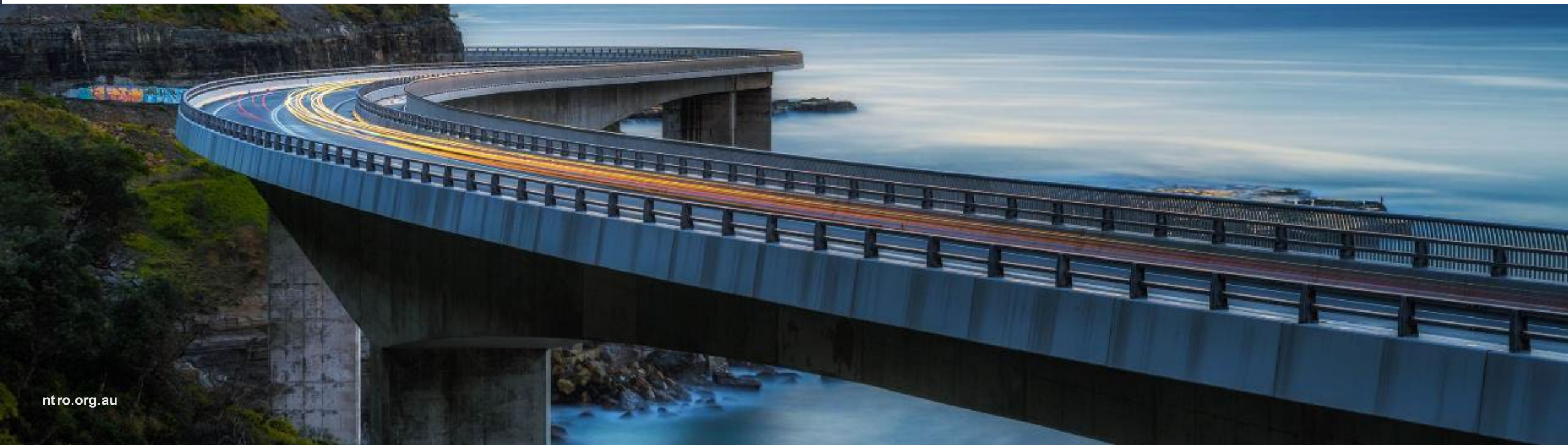




Innovation
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Fundamentals of Crumb Rubber in Road Infrastructure

Anna D'Angelo

Director Industry Partnerships and Technology

Strategic Delivery

9 June 2026



Innovation Driven

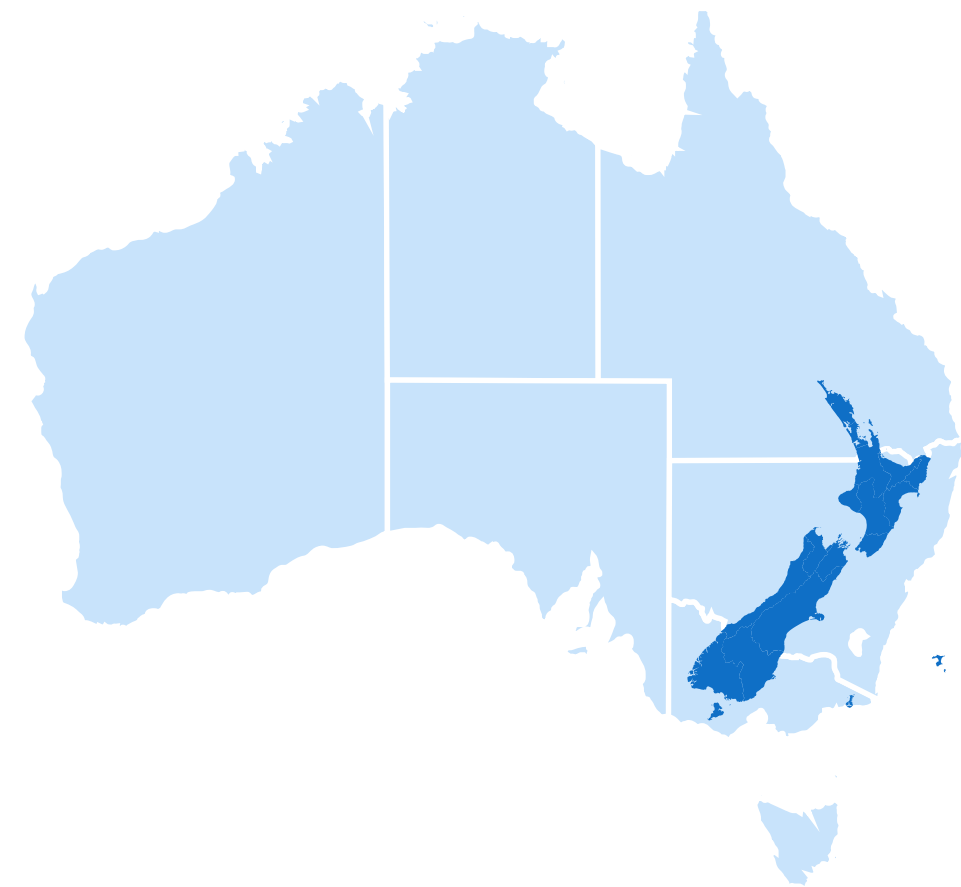
Agenda

1. Crumb rubber use in roads in Australia
2. Crumb rubber as a bitumen modifier
3. Environmental and technical benefits
4. Recent demonstration projects





	Australia	NZ	Ratio
Land area (km ²)	7.7 Million	267,710	x28
Population (million)	26.9	5.1	x5.3
Unemployment	4.3%	5.2%	
GDP / person	\$14,767	\$11,359	x1.3
Roads total length (km)	877,650	96,000	x9.1
Roads sealed (asphalt & chip seal) (km)	463,000	52,800	x8
Asphalt (million tonnes/annum)	~10	~1.6	X6.3



≈ 3,000 km

Common Australian Pavements

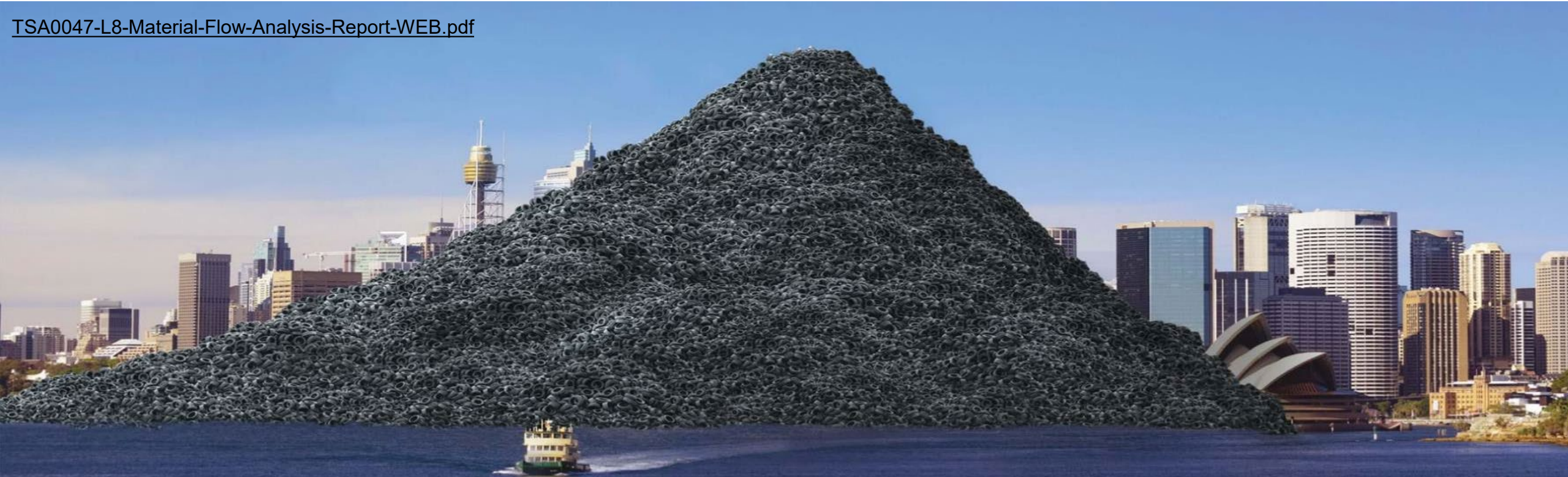
- Road network 800,000 km
- ~ 80% of surfaced road network sealed with spray seals
 - Cost effective solution
 - Suited to the scale and needs of Australia's network
- Asphalt is the premium choice for urban and high traffic roads



Tyre in Australia

- Annual tyre consumption (new tyres): 705,000 tonnes (74 million EPU)
- Annual Used tyre generation: 537,000 tonnes
- Combined recovery rate: 66% (>85% for automotive tyres; 13% OTR)

[TSA0047-L8-Material-Flow-Analysis-Report-WEB.pdf](#)



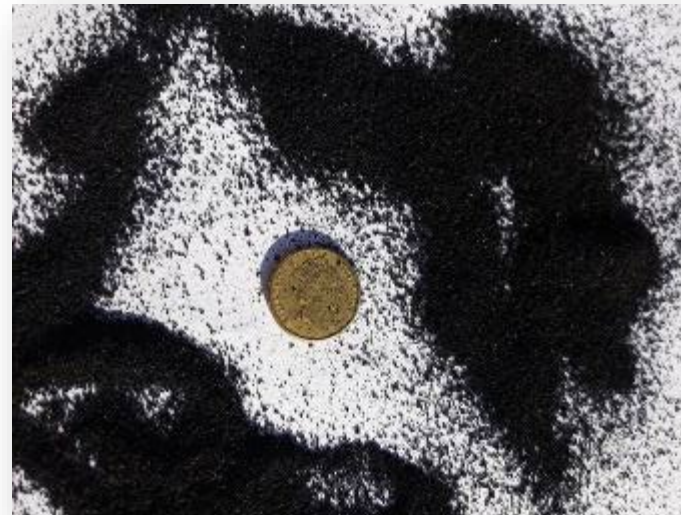
Crumb rubber use in Australia

- NSW 1960s first known use of crumb rubber in sprayed seals
- Sprayed sealing widely established
- Provides durable and well-suited solution for Australia network
- Asphalt research started ~ 2014



Road Grade Crumb Rubber

- Tyre collection
- Shredding and removal of non rubber content
- Shredded rubber is mechanically ground into rubber chips → rubber granules
→ final product → Road grade crumb rubber = 30 mesh



AUSTROADS TECHNICAL SPECIFICATION ATS 3110 Supply of Polymer Modified Binders



Contents

1. Scope.....	1
2. Referenced Documents.....	1
3. Definitions.....	2
4. Quality System Requirements.....	2
5. Manufacture of Binders.....	3
6. Sampling and Testing of Binders.....	3
7. Records.....	4
8. Properties of Binders.....	4
9. Frequency of Testing.....	8
Annexure A: Summary of Hold Points, Witness Points and Records.....	9

1. Scope

- 1.1 Austroads Technical Specification ATS 3110 sets out the requirements for the supply of polymer modified binders (PMBs) and crumb rubber modified binders for use in both sprayed sealing and asphalt applications.

2. Referenced Documents

- 2.1 The following documents are referenced in this Specification or are relevant to this Specification:

Australian / New Zealand Standards

- AS/NZS 2341.4: Methods of testing bitumen and related roadmaking products: determination of dynamic viscosity by rotational viscometer
- AS 2341.18: Methods of testing bitumen and related roadmaking products: determination of softening point (ring and ball method)
- AS/NZS ISO 9001: Quality Management Systems: Requirements.

Dry Method

- Coarser rubber particles
- Rubber added to hot aggregates
- No special adjustments at the plant
- Lack of chemical interaction between bitumen and rubber (inert material, 'elastic aggregate')

Wet Method

- Finer rubber particles
- Rubber added to hot bitumen → bitumen modification
- Plant requires adjustments
- Greater fatigue/rut resistance, high viscosity can generate workability issues in the field



Crumb Rubber modified bitumen

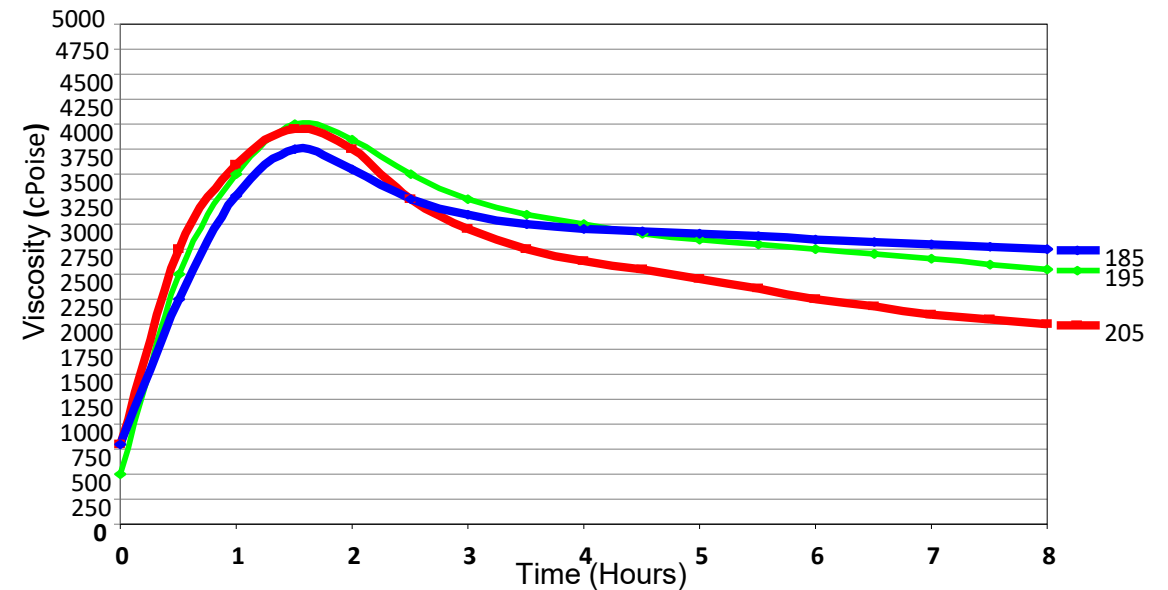
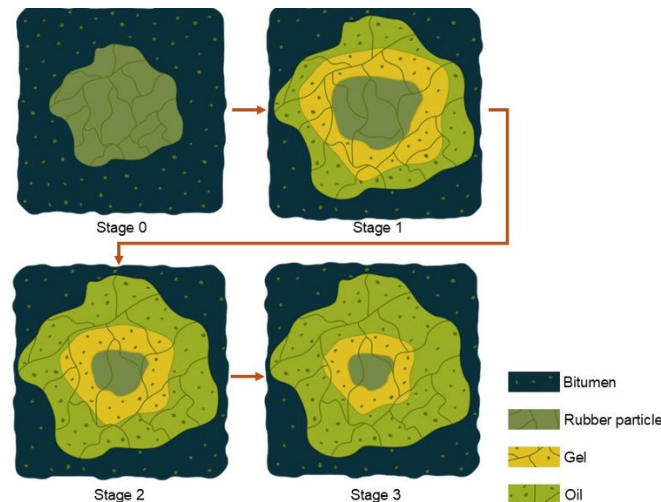
Wet blending process

- Bitumen (Class 170) blended with crumb rubber (size#30 mesh)
- Two-phase system: rubber particles partially digested and can separate

Schematic illustration of crumb rubber swelling due to the absorption of the bitumen's light components

Digestion occurs in different stages:

1. Light phase of bitumen is adsorbed
2. Rubber changes into a gel like material
3. Rubber changes into an oil.



Main sources of crumb rubber

- Truck tyres
- Passenger car tyres
- Off the road (OTR) tyres

OTR include tyres from:

Tractors (agriculture, construction)	33.6%
Aircrafts (aviation)	2.9%
Forklifts (manufacturing and trade)	2.3%
Earth movers (mining)	61.2%



Crumb rubber bitumen Specifications

Table 8.1: Properties of Polymer Modified Binders for Sprayed Sealing Applications

Test method	Class	S10E	S15E	S20E	S25E	S35E	S9R ⁽¹⁾	S15R ^(1,6)
	Binder property							
AS/NZS 2341.4 or ATM-111 ⁽²⁾	Viscosity at 165 °C (Pa.s) max. ⁽²⁾	0.55	0.55	0.6	0.9	0.55	1.5	4.5 ⁽²⁾
ATM-122	Torsional recovery at 25 °C, 30 s (%)	22–50	32–62	38–70	55–80	16–32	15–45	25–55
AS 2341.18	Softening point (°C)	48–64	55–75	65–95	82–105	48–56	50–60	55–65
AGPT/T125	Stress ratio at 10 °C min.	TBR ⁽³⁾	TBR	TBR	TBR	TBR	TBR	TBR
AGPT/T121	Consistency 6% at 60 °C (Pa.s) min. ⁽⁴⁾	300	400	500	900	250	400	800
AGPT/T121	Stiffness at 15 °C (kPa) max.	140	140	NA ⁽⁵⁾	NA	180	NA	180
AGPT/T121	Stiffness at 25 °C (kPa) max.	NA	NA	35	30	NA	NA	NA
ATM-132	Compressive limit at 70 °C, 2 kg (mm) min.	NA	NA	NA	NA	NA	0.1	0.2
AGPT/T108	Segregation (%) max.	-8 to +8	-8 to +8	-8 to +8	-8 to +8	-8 to +8	-8 to +8	-8 to +8
ATM-112	Flash point (°C) min.	250	250	250	250	250	250	250
ATM-103	Mass Change (%)	-0.6 to +0.6	-0.6 to +0.6	-0.6 to +0.6	-0.6 to +0.6	-0.6 to +0.6	-0.6 to +0.6	-0.6 to +0.6

Table 8.3: Properties of Field-Produced Crumb Rubber Binders

Property	Method	S9RF ^(1,2)	S15RF ^(1,2)	S18RF ^(1,2)	A27RF ⁽³⁾
Nominal rubber concentration (%)		9	15	18	25–30
Rubber content by analysis (%) min.	AGPT/T142	7	13	16	–
Torsional recovery (%) min.	ATM-122	15	25	30	–
Softening point (°C) min.	AS 2341.18	50	55	62	–
Consistency 6% at 60 °C (Pa.s) ⁽⁴⁾	AGPT/T121	Report	Report	Report	–

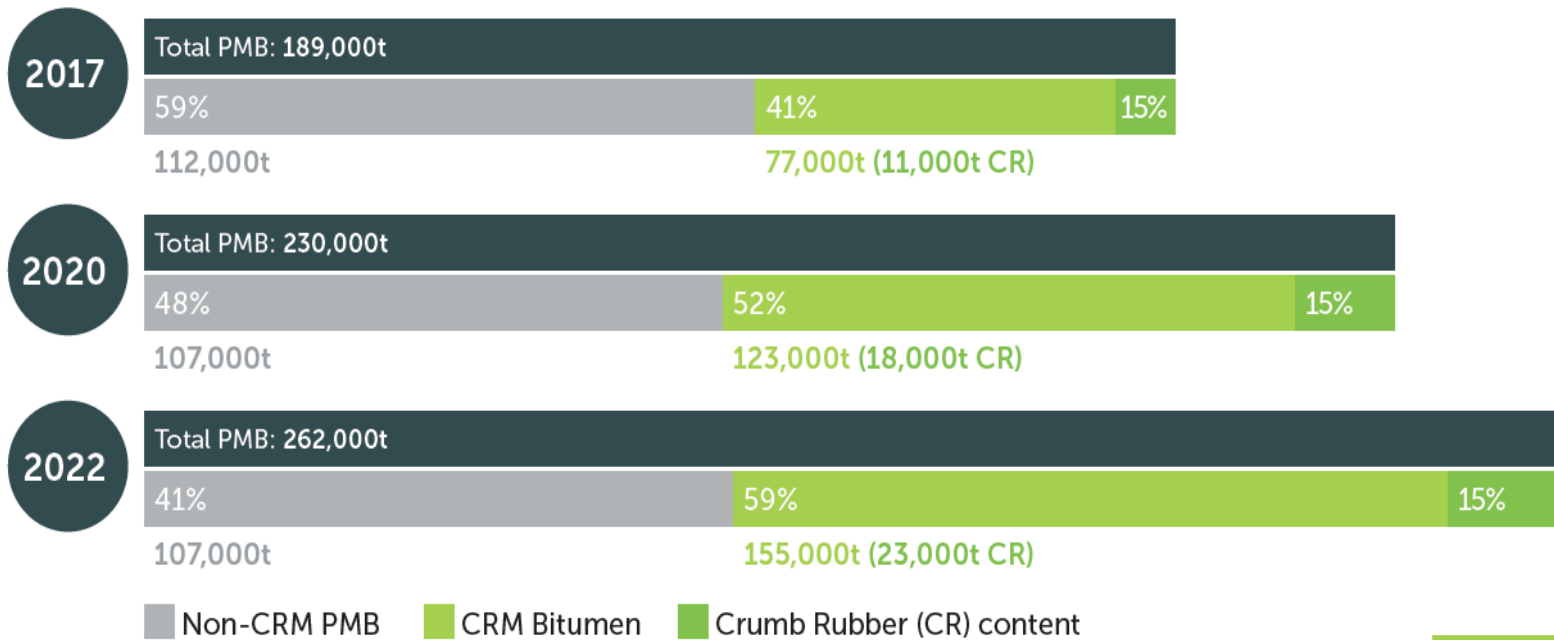
Table 8.2: Properties of Polymer Modified Binders for Asphalt Applications

Test method	Class	A35P	A20E	A15E	A10E	A5E	A18R ⁽¹⁾
	Binder property						
AS/NZS 2341.4 or ATM-111 ⁽²⁾	Viscosity at 165 °C (Pa.s) max. ⁽²⁾	1.1	0.6	0.9	1.1	0.9	6.2
ATM-122	Torsional recovery at 25 °C, 30 s (%)	6–30	38–70	55–80	60–86	25–40	30–70
AS 2341.18	Softening point (°C)	62–74	65–95	82–105	88–110	82–105	62–80
AGPT/T125	Stress ratio at 10 °C min.	TBR ⁽³⁾	TBR	TBR	TBR	TBR	TBR
AGPT/T121	Consistency 6% at 60 °C (Pa.s) min. ⁽⁴⁾	1000	500	900	1000	2500	1000
AGPT/T121	Stiffness at 25 °C (kPa) max.	120	35	30	30	NA	NA ⁽⁵⁾
AGPT/T121	Stiffness at 25 °C (kPa) min.	NA	NA	NA	NA	90	NA
ATM-132	Compressive limit at 70 °C, 2 kg (mm) min.	NA	NA	NA	NA	NA	0.1
AGPT/T108	Segregation (%) max.	-8 to +8	-8 to +8	-8 to +8	-8 to +8	-8 to +8	-8 to +8
ATM-112	Flash point (°C) min.	250	250	250	250	250	250
ATM-103	Mass Change (%)	-0.6 to +0.6	-0.6 to +0.6	-0.6 to +0.6	-0.6 to +0.6	-0.6 to +0.6	-0.6 to +0.6

Australian Specifications

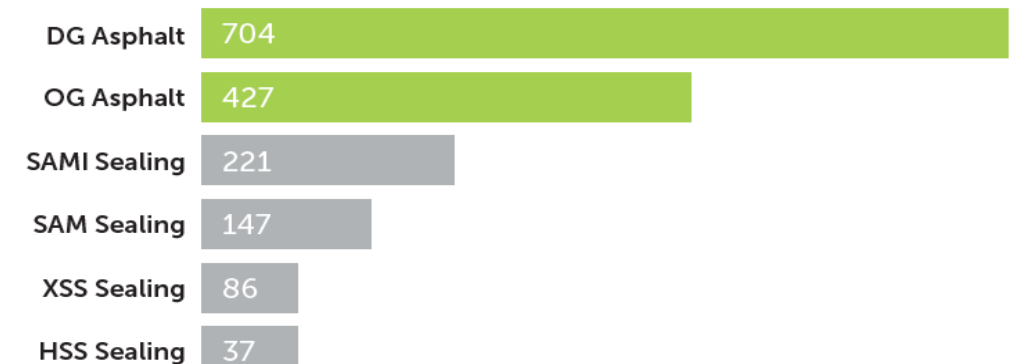
- AfPA model specification for wet-method crumb rubber asphalt (GGA&OGA > 18% CR content)
- TMR
 - PSTS 112 (2017, updated in 2019)
- MRWA Specification
 - 511 “Material for bituminous treatment”
 - 516 & 517 Crumb Rubber OGA&GGA (2018, 2020)
- DoT Vic specification
 - Section 421 High binder crumb rubber asphalt
 - Section 422 Light Traffic Crumb Rubber Asphalt (2019)
- TfNSW Specification – *Dry method*
 - 118 “Crumb rubber asphalt”
 - DC3256 “Crumb rubber”

Crumb rubber used in Australia in asphalt



Volume of crumb rubber likely to increase due to uptake in asphalt applications

EPU per lane km against treatment type



Research to Implementation

2014 - 2025



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2014 - 2016

**NACOE projects P31/P32
WARRIP project**

- Optimising the use of crumb rubber modified bitumen in QLD
- Transfer of crumb rubber technology to WA - OGA

[Nacoe project_P31-P32-Optimising-the-use-of-crumb-rubber_Yr1-2014-15-Final.pdf](#)



2017

NACOE Project P31

- Transfer of Crumb Rubber Modified Asphalt Technology to Queensland (Phase 2)
- Emissions Monitoring (spray sealing and asphalt applications)

[Nacoe_P31-Transfer-of-crumb-rubber-technology-to-QLD-phase-2_Final.pdf](#)



2019

WARRIP

- Transfer of crumb rubber technology to WA – GGA
- Investigating the use of reclaimed asphalt pavement from asphalt containing crumb rubber modified binder

[Transfer of Crumb Rubber Modified Bitumen Technology to Western Australia | WARRIP](#)



2020

Austroads

- Passenger Cars and other Non-Truck Tyres National Market Analysis, Review of Industry Practices and Technology Transfer and demonstration project





WARRIP

WARRIP (2020-2022-2024)
Digestion of crumb rubber in bitumen



LG TRRIP

Crumb rubber modified binders in
asphalt applications and sprayed
seals on local government roads in
WA



LG TRRIP

Practitioners' Guideline: Crumb
Rubber Modified Binders in sprayed
seal applications on Local
Government roads in WA



Research & Development

Understanding material behaviour

- Digestion of the crumb rubber in bitumen and effect of different rubber sources
- Dense graded asphalt application for local governments

Demonstration projects

Proof of concept, adapt to local conditions

Validation of other rubber sources (OTR) and technologies to fully exploit the performance improvements

Building capability

Market assessment

Understand the barriers to growth and support solutions

Skills development

Training and awareness
Practitioners' guidelines

Support Adoption and uptake

Raise awareness
on the benefits and share the learnings
Life cycle assessment

Technical and Environmental benefits



Innovation Driven

Spray sealing

- 5% - 18% crumb rubber by mass of binder
- S15R, S15RF, S18RF used nationally for seals in high demand situations; heavy traffic, or over cracked pavement
- 5% crumb rubber used in Victoria as tough resilient seal on light trafficked roads and to improve aggregate retention on heavy traffic roads



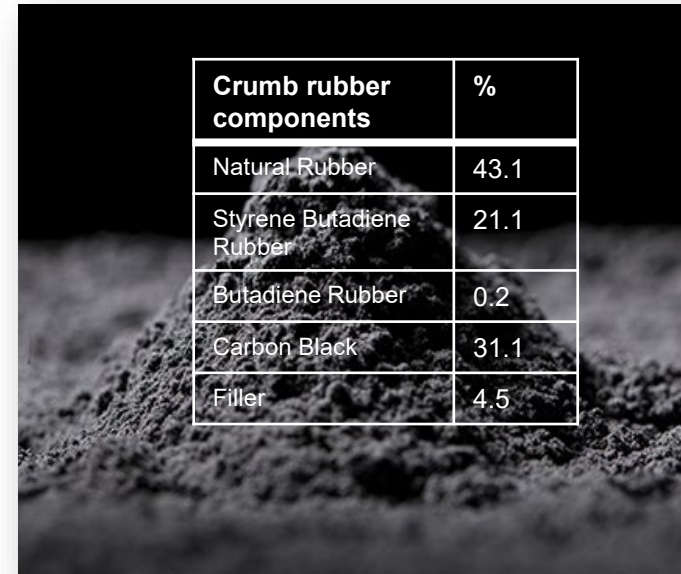
Asphalt

- Open Graded asphalt (OGA): 18% - 20% CR by mass of binder
- Gap Graded Asphalt (GGA): 18% - 20% CR by mass of binder
- Dense Graded Asphalt (DGA): 10% -15% CR by mass of binder



Technical Benefits

- Rubber and carbon black represent approximately 70% of the weight of a tyre.
- Rubber acts as bitumen modifier
- Carbon black acts as a 'sunscreen'
- Crumb rubber modified bitumen (CRMB) has enhanced elastic and anti ageing properties → more durable roads



Crumb rubber components	%
Natural Rubber	43.1
Styrene Butadiene Rubber	21.1
Butadiene Rubber	0.2
Carbon Black	31.1
Filler	4.5



Key performance Enhancements

Sprayed seals

- Enhanced Cohesion and Aggregate retention
- Delayed oxidation cracking and stone loss
- Superior resistance against reflective cracking
- Better performance under high stress

Asphalt

- Higher binder film thickness, and elastic recovery deliver proven durability improvements and retard ageing
- Higher rutting resistance
- Superior cracking resistance



Neat bitumen



15% Crumb rubber bitumen

Asphalt Performance Testing

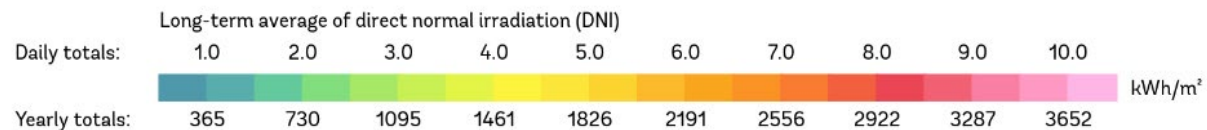
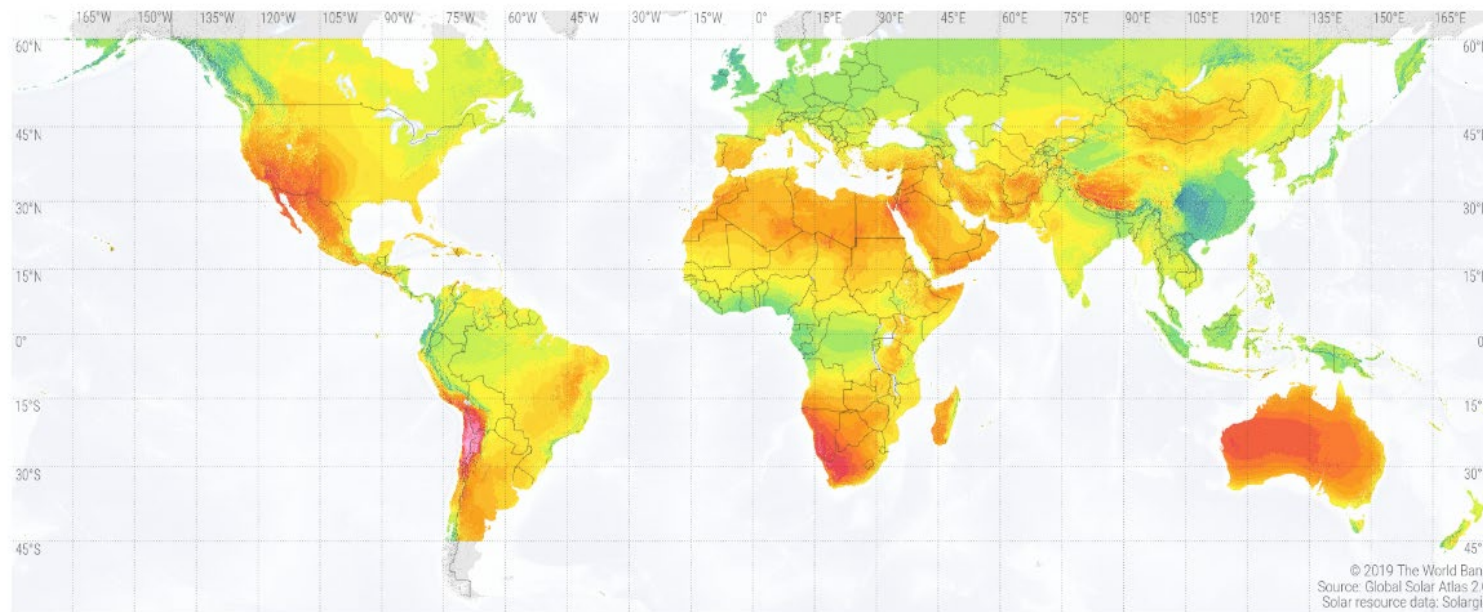
Cracking Tolerance (Ideal-CT)	Test Method	BCC2 (C320)	AC14 (A15E)	GGA10 (OTR CR18)	GGA7 (OTR CR18)	GGA7-UHB (OTR CRB 18)
CT Index - Aged Specimens	ASTM D8225	56	177	940	1950	4213
CT Index - Unaged Specimens		125	197	1014	3407	7631



Binder UV aging

SOLAR RESOURCE MAP

DIRECT NORMAL IRRADIATION



Australian roads are exposed to a significant amount of UV radiation

- UV ageing conducted on binder samples used in the field
- Samples exposed in laboratory to equivalent solar radiation of 1 year on Sunshine Coast
- Data showed a reduction of UV damage of approximately 42% when crumb rubber is used in the bitumen as a modifier.

Environmental benefits

- Reduced exposure to harms by illegal tyre dumping and stockpiling
- Recovery of resources
- Energy and GHG emissions



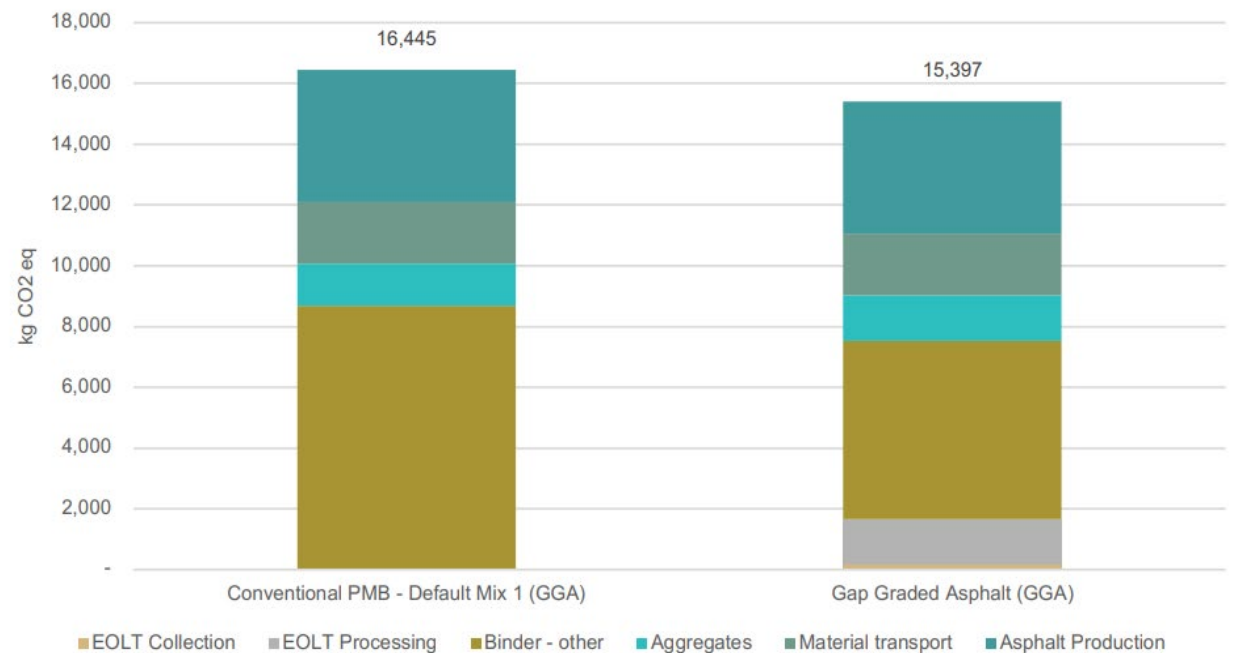
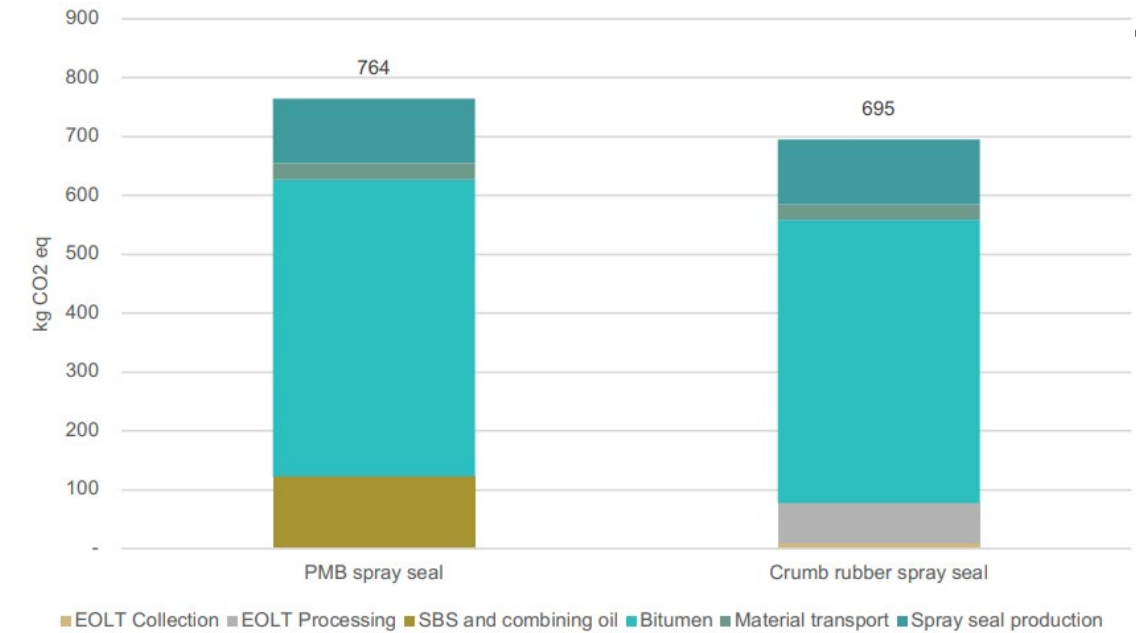
Environmental impact

- **9% GHG emission reduction from crumb rubber sprayed seal vs PMB sprayed seal**

- **Average 7% GHG emissions reduction from a wet process asphalt mix compared to a PMB asphalt mix required in 1 km of road**

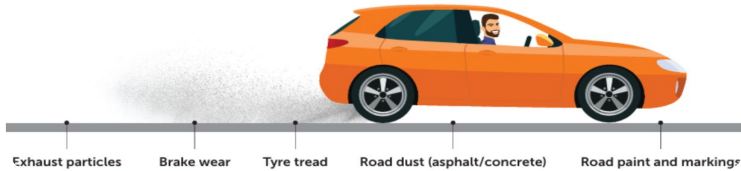
Cradle to gate calculations

[*TSA-Life-Cycle-Assessment-of-end-of-life-tyres.pdf](#)



Tyre Road Wear Particles

5–250 µm particles from tyre-road friction.



Crumb Rubber

0.5–1.2 mm granules added to bitumen for roads.

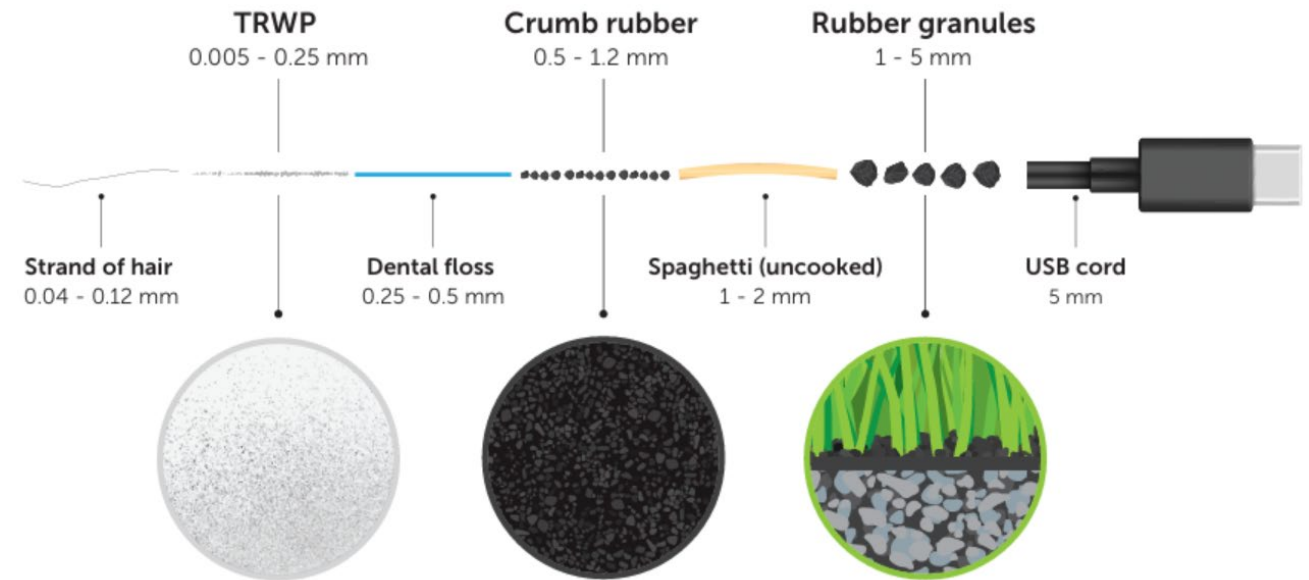


Rubber Granules

1–5 mm granules used as infill in artificial turf and bound into playground



Tyre Particle Health, Environment and Safety Report (TSA)



Particles in TDM have a minor risk to the surrounding environment.

Initial barriers and solutions



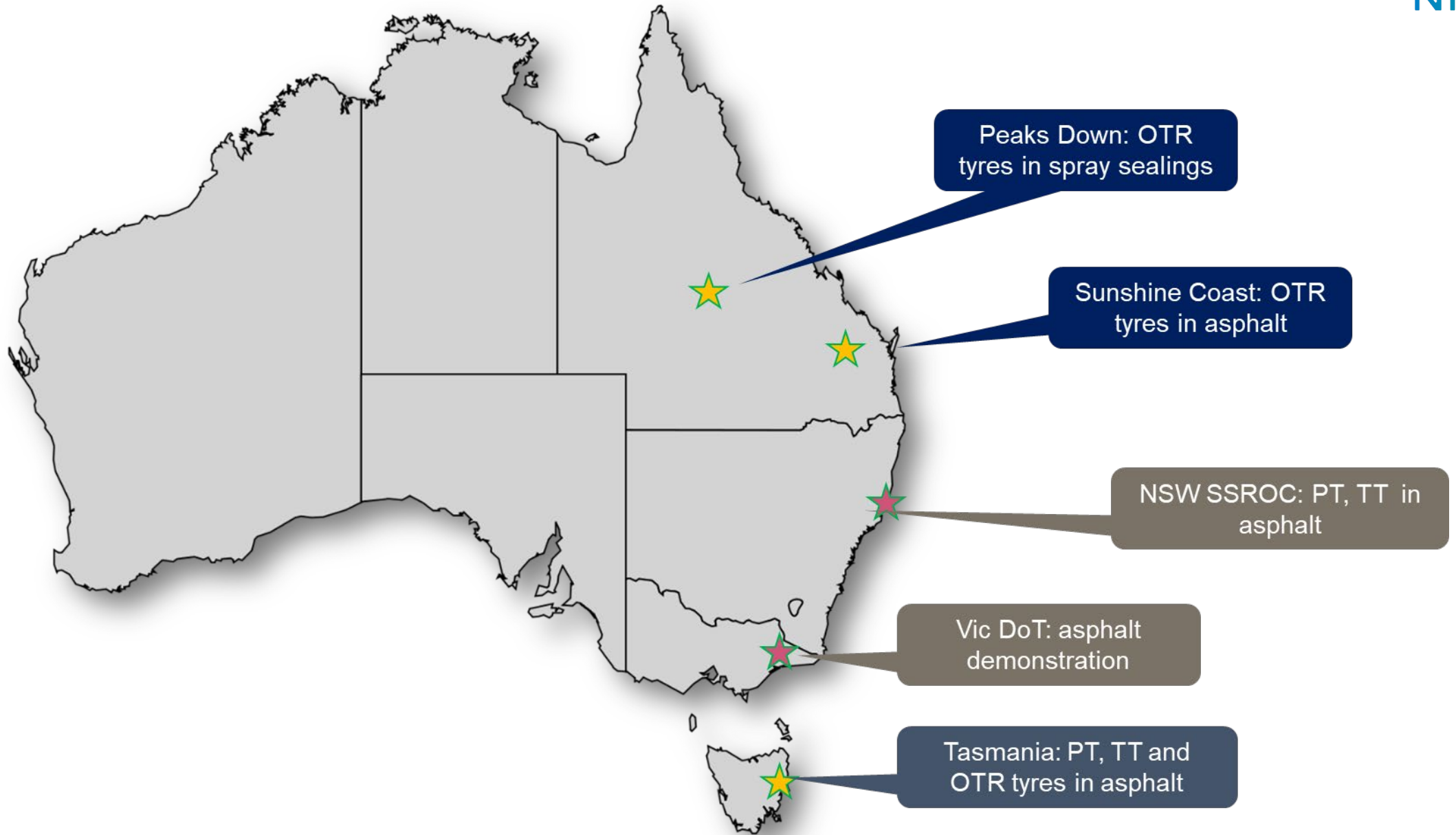
- Specifications on crumb rubber asphalt
- Concerns about worker exposure and environmental impact (fumes, microplastics)
 - lower asphalt temperatures is now standard practice
 - research studies did not identify harmful emissions above recommended limits
 - same for leaching and water quality TSA Tyre Particle Safety Report (tyrestewardship.org.au)
- Initial increased road construction costs
 - most findings indicate that these are more than offset by the increased performance life of the pavement
- Reuse of RAP with Crumb rubber bitumen – WARRIP study (<https://warrip.com.au/projects/crm-rap/>)

Case studies



terro

Innovation Driven



OTR mining tyre

- Location: Peaks Down Highway
- Main link between Whitsunday Coast and Central West region near Moranbah mining heartland
- High percent of Heavy Vehicles
- Project supported by NACOE research program



Department of Transport and Main Roads

Central Queensland mining tyres recycled to resurface highways

In a Queensland first, giant tyres from mining vehicles have been used to resurface a major CQ highway.



'Full circle': New lease of life for mining tyre waste

In a Queensland-first, giant tyres from mining vehicles have been used to resurface a major Central Queensland highway.

News

News

All

BHP partners on OTR tyre recycling and repaving project in Queensland

Posted on 25 Sep 2023



In a Queensland first, crumb rubber created from giant mining tyres has been used in a trial to resurface one of Queensland's major highways, BHP reports.

- Location: Peaks D
- Main link between region near Morar
- High percent of Heavy Vehicles
- Project supported by NACOE research program



The tyres

Two BHP mining tyres - 59/80R63

- over 4m in diameter
- weighed 4.2 tonnes each
- high natural rubber content (> 30%)
- high carbon black content



Department of Transport and Main Roads

Peak Downs Highway project



- 7 km sealed road
- 7 tonnes crumb rubber (S15R)
- Two 63" mining tyres

Circular Economy opportunity

Sunshine Coast Council Demonstration project

- Identified opportunity for use of Boral Quarry sourced OTR tyres
- Manufactured 10 tonnes of #30 Mesh OTR CR for use on the project
- Asphalt mixes with 18% CR (in bitumen) compared to control sections





Before



After



Before



After

Project in numbers

- 7,791 m² of asphalt
- 572 tonnes of asphalt
- 10,000 kg of OTR Crumb Rubber



Before



After

Asphalt Performance Testing

Cracking Tolerance (Ideal-CT)	Test Method	BCC2 (C320)	AC14 (A15E)	GGA10 (OTR CR18)	GGA7 (OTR CR18)	GGA7-UHB (OTR CRB 18)
CT Index - Aged Specimens	ASTM D8225	56	177	940	1950	4213
CT Index - Unaged Specimens		125	197	1014	3407	7631

Rut resistance increased (> 20% depending on content and mix design)



Neat bitumen



15% Crumb rubber bitumen



Austroads Project

- Client: Department of State Growth
- Location: Tasman Highway - Significant route for all oversize activities
- Contractor: Fulton Hogan
- Crumb Rubber bitumen: S15 R



Truck, passenger car and OTR tyres

- Three types of crumb rubber from three different sources
 - radial tyres from Boral quarry (earthmovers)
 - passenger car tyres
 - truck tyres
- Manufactured by Carroll Engineering Services
- No changes to the production process at the recycling plant

Crumb rubber materials were checked to assess their gradation (30# mesh), moisture content (less than 1%), and presence of metal (less than 0.1%)



Road condition & treatment

- Localised areas of crocodile cracking in the existing surface layer
- Irregularities on the surface, including small potholes
- Signs of previous crack sealing were visible on the surface.
- Asphalt: AC10 Light Traffic Crumb Rubber Asphalt with S15R with different CR source

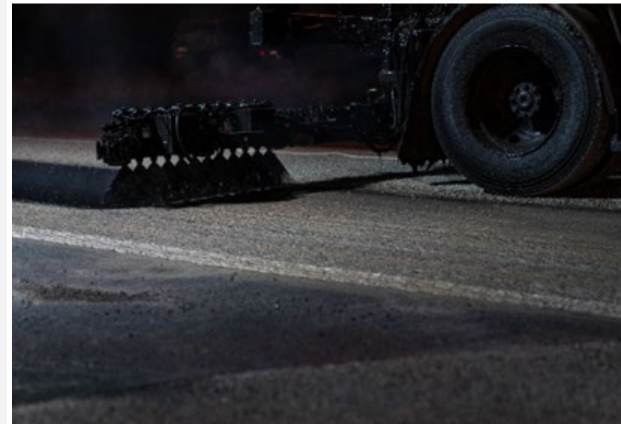


Austroads project

1. No significant adjustments to manufacture crumb rubber-modified binder.
2. Crumb rubber-modified binder properties were similar.
3. Asphalt manufacture didn't require adjustment in terms of mixing temperature or batching time.

Project in numbers

- 5,700 m² asphalt
- 462 tonnes asphalt
- 3,950 kg of CR



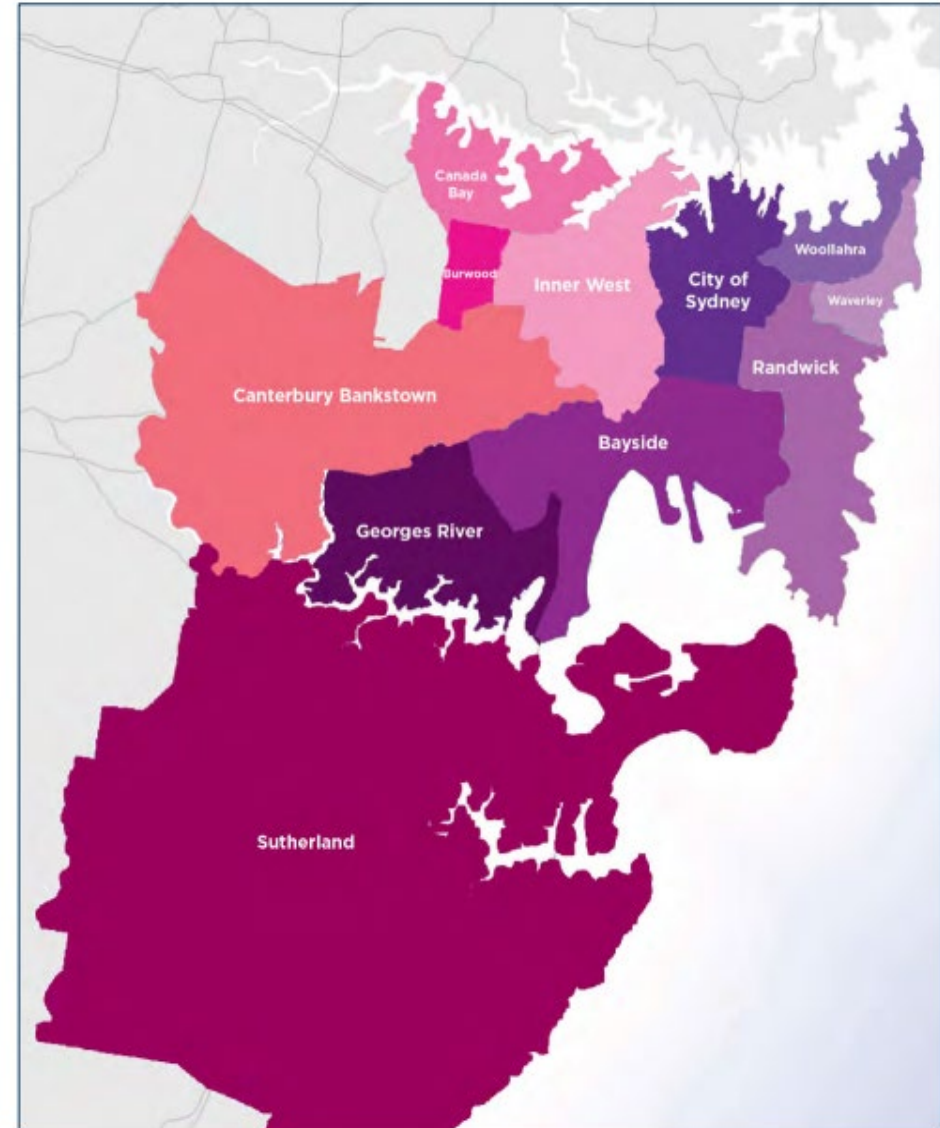
SSROC

Southern Sydney Regional Organisation of Councils

- Funded by TSA
- Paving the Way Project
- Improve the sustainability of local roads and create market for EOLT
- Multi-council demonstration project to enable the use of crumb rubber in asphalt

Project in numbers

- 12 councils
- > 40,000 m² of asphalt
- ~ 28,500 kg of CR
- RAP, RCG included



Conclusion

Progress and adoption of crumb rubber relies on 5 critical stages:

- Research & Development
- Demonstration projects
- Specifications
- Manufacturing capacity and capability
- Collaboration between industry, research and government



THANK YOU



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