Removing Barriers to Use of Crumb Rubber
NZTA Research Report 578

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Opus Research
Acknowledgements

- NZ Transport Agency
  - Research Report 578, 2015 (An output of NZTA Research Project ART14-26)

- REAAA
  - Roadshow 2016

- Fulton Hogan
  - Technical support – manufacturing and trials

- Rubber Solutions Asia Pacific Limited
  - Material supplier

- Pacific Renewables Limited
  - Material supplier
Presentation Outline

- Background
- Highlights from the Latest NZTA Report
- Recent Development and Opportunities

REAAA Roadshow 2016
What is Crumb Rubber?

- A product of end-of-life tyres
- 60,000+ tonnes of end-of-life tyres annually in NZ (2014)
- Many uses including tyre-derived fuels and bitumen binder modifier
Typical Uses for Tyre-Derived Rubber in NZ
Aim

- Transport
  - To enhance performance of roading infrastructure

- Environment
  - To divert a high priority waste stream away from landfills
Potential Benefits of Modified Binders

- Better chip adhesion / aggregate retention
- Increased elasticity
- Crack resistance
- Rutting resistance
- Reduced fatigue failure
- Less temperature sensitive
- Less maintenance / repairs
- Longer lives
Added Benefits of Crumb Rubber

- Alternative to virgin polymer pellets
- Locally sourced
- More stable pricing (NZ$750- NZ$1000 per tonne)
- Security of supply
- Bitumen extender
- Potentially less bitumen and virgin polymer need to be imported into NZ
Report outline

- Literature review and stakeholder consultation project funded by NZTA
  - International state-of-the-art
  - National state-of-the-art
  - Historical barriers and current barriers
  - Technology advancement
  - Environmental impacts
  - Recycling
Background

- History
  - 1990s enforcement for all states in the US
  - Currently, actively used in California, Arizona, Texas in the US
  - Australia has a track record in crumb rubber sprayed seals
  - NZ – one trial was published in the 90s (dry process)

References:

- Central Laboratories Report No. 6-82/2 (1983)
  - Google Search – “NZTA research report 578”
Crumb Rubber in Roads

• Well-established technology with ongoing improvements and innovations
• Alternative to polymer modification of bituminous binders
  • PG - Performance graded asphalt binders
  • Austroads AGPT/T190 – Specification framework for PMBs (incl. crumb rubber)

Dry process

Wet process

Rubber Pavements Association

Asphalt Rubber Usage Guide, Caltrans
Dry Process vs. Wet Process

**Dry Process**
- Higher binder content required
- Absorbed into the rubber crumb
- Patented process and unique gradation
- Introduction of crumb rubber into asphalt plants
- Higher mixing temperature

**Wet Process**
- Intimate interaction
- Ultrafine (At least 30-mesh) crumb rubber preferred
- Highly modified binder
- Typically high viscosity
- Typically specialist equipment
- Typically thicker film
- Used in both chip seal and hot mix asphalt
- Vast experience across the world
Key Findings – Current Barriers in NZ

- High initial cost
  - Capital equipment

- Market demand
  - Small PMB market ~ 5% of total bitumen market, predominantly in asphalt when compared to chip seals

- Security of supply
  - End-of-life tyres (ELTs) are still finding their way into landfills

- High temperature – health and safety
  - Difficult to be emulsified
Various Forms of Crumb Rubber

- Crumb rubber
  - Mechanically ground (ambient/cryogenic)
  - Rubber powder / granule (70%), steel and textile (30%)
  - Mesh size – cost increases exponentially with decreasing size (higher mesh#)

- Devulcanisation
  - Thermal/Chemical/Mechanical process
  - Removes cross-linking network of rubber (lower molecular weight)
  - Easier interaction with hot bitumen
  - Potential substitute for virgin polymer resin
Devulcanisation

- **Conventional devulcanisation**
  - High pressure, high temperature

- **New-generation**
  - Atmospheric pressure, lower energy requirement
  - More environmentally friendly and cost-effective
In order for a sustainable uptake of crumb rubber, we need to have:

- Demand for modified binders
  - Economy of scale
    - Current PMB use ~5% of total bitumen market (say 150kT)
- Sustainable and secure supply of ELTs
  - 60,000 tonnes of ELTs (25% are truck tyres)
  - To cope with potential market growth
    - **Hypothetical scenario:** If market grows to 25%, 7,500 tonnes of rubber may be consumed (at dosage of 20%)
- Technology capability (from contractors’ p.o.v.)
  - Enabled by devulcanised rubber
  - Existing binder modification plants
  - Minimise unnecessary capital investment
  - Ability to be emulsified
Recommended Actions to Remove the Barriers

- **Growth of market**
  - Assess/Quantify the performance benefits of currently used PMBs over unmodified binders in chip seals and asphalt
  - Evaluation of rubber modified binders against PMBs
    - Feasibility project on the use of devulcanised rubber for asphalt

- **Devulcanised tyre rubber**
  - Verification of field performance of modified binders and the assessment of the ability to be emulsified
Current Work

- Pacific Renewables Limited
  - Supplying devulcanised rubber
  - Currently in the process of establishing a plant in NZ

- Lab assessments (Opus Research and Fulton Hogan)
  - Confirmed enhanced rheological properties of binders
  - Modified by various amounts of devulcanised rubber up to 20wt%
  - Dense-graded asphalt mixes were assessed in controlled lab environment
  - **Improved fatigue lives** using indirect tensile fatigue tests compared against 4%SBS PMB as well as unmodified

- Concerns around binder compatibility and storage stability
  - Further work needs to be done to address variation in binder supply
Effect of Crumb Rubber – Creep Recovery

Tensile Strain at 0ºC

Tensile Test – conducted at 0ºC at 150mm/min
Where to from here?

- **Workability / lay-down trial**
  - Logistics of binder modification and asphalt mix production
  - By end of October 2016

- **Odour testing**
  - Stack emission

- **Field trial**
  - Cycleways to be laid following the lay-down trial

- **Completion of binder performance benefit assessment**

- **Reclaimed Asphalt Pavement (RAP)?**
  - How to recycle tyre-rubber modified asphalt and chip seals?
Other Road Surface Applications – Cycle tracks

- In relation to roading
  - Same paving technology
  - Less stringent performance requirement
- Enhanced performance
  - Elastic
  - Crack resistant
  - Reduced maintenance requirements
For More Information

**Research Report 578** Removing barriers to the use of crumb rubber in roads
NZ Transport Agency website
www.nzta.govt.nz/resources/research/reports/578

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