Project Evaluation Report

Recycled Glass in asphalt

Strategic Waste Initiative Scheme: Contract 4004

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Pioneer Road Services is the leading road resurfacing company in Australia. Our experience and knowledge in road surfacing has been attained over a period of over 60 years in the business. Our experience extends to major resurfacing contracts in spray sealing and asphalt for State Road Authorities, Local Government, Airports and the Private Sector. Contracts have been undertaken in both remote and high density trafficked areas.

In addition to conventional surfacing materials Pioneer Road Services Pty Ltd is able to produce specialised products to suit a wide range of applications including:

- Polymer modified asphalt
- Bitumen Treated Base
- Heavy duty pavements
- Coloured asphalt
- Crack sealing
- Stone Mastic Asphalt (SMA)
- Recycled asphalt (RAP)

Recent initiatives and innovative approaches have lead to trials incorporating crushed recycled glass in asphalt mixes. Benefits associated with incorporation of glass include reduction of costs through waste reduction, raw material savings and enhanced asphalt characteristics. The use of waste materials in asphalt is very appealing to the local councils and the West Australian and Federal Governments.
1. INDUSTRY OVERVIEW

The minimization of waste produced by various industries, construction sites, homes etc. is a great concern in most countries.

Statistics relevant to the amount of waste generated by various countries shows Australia in a second place to the USA with a figure 50% higher than Canada:

<table>
<thead>
<tr>
<th>Country</th>
<th>Waste per person per year (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>0.88</td>
</tr>
<tr>
<td><strong>Australia</strong></td>
<td><strong>0.74</strong></td>
</tr>
<tr>
<td>Canada</td>
<td>0.50</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.40</td>
</tr>
<tr>
<td>Japan</td>
<td>0.35</td>
</tr>
<tr>
<td>Germany</td>
<td>0.34</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.32</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.28</td>
</tr>
<tr>
<td>France</td>
<td>0.26</td>
</tr>
<tr>
<td>U.K.</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Kerbside collection of recyclables is now extensive in Australia, but efficiencies of this operation vary in many regions. As the nation focuses on environmental waste reduction, it is expected that recycling levels will increase into the future. Australia currently recycles 44% of glass produced.

The collected glass is sorted by colour and recycled for the glass container industry while the smaller size mixed colored glass and plate glass is sent to landfills as a waste product.

Asphalt incorporating glass is basically the same as conventional hot-mix asphalt, except that 5% to 40% of the aggregate and/or sand is replaced by crushed glass.

**Glass Asphalt Advantages:**

- The surface appears to dry faster than traditional paving after rain because the glass particles do not absorb water.  
  - **Increase road safety**
- Glass asphalt surfaces are also more reflective than conventional asphalt  
  - **May improve night time road visibility.**
- Due to its glass content will hold heat longer than conventional asphalt  
  - **Easier to compact and cartage benefits over longer distances**
- Glass is not disposed in landfills offering environmental benefits and saving costs to local government  
  - **Waste reduction initiative**
- There are savings with regard to input costs of raw materials which are replace by glass.  
  - **Commercial benefits**
Use limitations:
✓ When the glass content exceeds 15% of the total mix, stripping problems can occur so it is necessary to add 1% anti-stripping agent.
✓ The crushing process can generate dust if not monitored adequately.

**Competition**
At this stage there is no other use for the glass in the asphalt industry or any other industries.

### 2. HISTORY

Pioneer Road Services WA carried out the first Glass mix trials in Australia. The mix was produced at the Hazelmere plant and placed on Glennon Way within the City of Canning in February 2003. The second trial was performed on Ranford Rd. In April 2003 with the assistance of Main Roads WA, City of Canning and the Police Department the glass asphalt, Stone Mastic Asphalt and conventional dense grade asphalt were compared for skid resistant properties. The research involved controlled skidding stops of a calibrated vehicle.

The Police Department showed that the skid resistance and braking time on the asphalt containing glass is similar, if not slightly better than conventional dense grade mix.

### 3. BUSINESS STRUCTURE

PRS has been in negotiations with the South Metropolitan Regional Council (SMRC) who are a statutory local government authority established by 7 local Councils in the southern part of metropolitan Perth. It is responsible for developing waste management solutions for the communities of Canning, Cockburn, East Fremantle, Fremantle, Kwinana, Melville and Rockingham.

Discussions originally too place at a meeting between PRS and SMRC in 2006. The following was agreed and was formalized in an exclusive supply agreement.

PRS presented a Statement of Intent to the SMRC which incorporates the following points:

- Pioneer Road Services is responsible for purchasing and installing a glass crushing and screening plant at PRS Hazelmere depot. The crushed and screen glass will be used in asphalt and the surplus product can be sold to alternative markets

- SMRC will supply Pioneer Road Services WA clean recycled glass free of charge; the available quantity is between 5,000 and 10,000 tones per annum.

- Pioneer Road Services is responsible for carting the glass cullets from the SMRC depot to the crushing plant at Hazelmere
4. Glass Crushing Plant

Table 1.0 – Summary of Plant Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Fixed, static plant</td>
</tr>
<tr>
<td>Capacity</td>
<td>10 to 20tph</td>
</tr>
<tr>
<td>Footprint L x W x H (metres)</td>
<td>12 x 8 x 4</td>
</tr>
<tr>
<td>Weight</td>
<td>5.00 Tonne</td>
</tr>
<tr>
<td>Feed System</td>
<td>In feed and out feed conveyor</td>
</tr>
<tr>
<td>Waste Separation</td>
<td>Trommel (for caps, labels etc)</td>
</tr>
<tr>
<td>Noise Level</td>
<td>Approx 85 Dba</td>
</tr>
<tr>
<td>Screen Sizes</td>
<td>1/2” - 3/8” 3/16” – 1/8”</td>
</tr>
<tr>
<td>Optional Extras</td>
<td>• Particle size separator</td>
</tr>
</tbody>
</table>

Note: particle size is dependant upon the selection of the screen, however the outcome is very much dependant upon the dryness of the material, type of glass, load levels etc.

Rule of thumb, the average break up is

- 10% to 20%, smaller than 0.5mm
- 25% to 65%, between 0.5mm and 2.5mm
- Balance above 2.5mm and below the maximum opening of the screen

The crushing plant was purchased from Its Green. The plant was manufactured in the USA but distributed in Australia for servicing and parts support.

The system consists of three stages:

1. POPPER UNIT – where the initial full glass containers are broken into smaller pieces

2. SHEARING UNIT – where the primary crusher process occurs, breaking the glass down to the desired thickness

3. SIZING UNIT – where the glass is screened to the desired size
The advantages of this unit compared to the other evaluated units are that the Its Green unit is:
- a one pass process (not continuous) that provides a labour efficient recycling system
- already proven technology and capabilities
- compact, easy to install
- crushes any size glass (jars, bottles)
- crushes glass size down to a minimum 2 mm size
- transportable in a shipping container if required

The plant unfortunately did not perform to expectations suffering significant wear after only processing a small volume of product. The supplier and local agent offered little assistance so at an additional cost, PRS had to replace the primary screen crusher with a conical crusher.

4. MISSION & STRATEGIES

Our mission and strategy with regard to the crushing and use of glass consists of the following:

Pioneer Road Services WA develops, manufactures and markets glass asphalt as part of an environmental and waste reduction initiative together with SMRC which indirectly involves local Government.

This finished asphalt product meets the Australian Standards and Local Government specifications for Particle Size Distribution, Bitumen Content and Volumetric properties required for conventional dense graded asphalt mixes.

Our strategy is to incorporate the glass in asphalt mixes thereby generating waste reduction and raw material cost savings.

We plan to expand the business, to develop additional markets and methods of incorporating the glass cullets into products manufactured by a diverse range of industries. These opportunities are discussed below:

**Alternative markets:**

- **Bricks**

Plate and container glass, when finely ground and heated, will soften and fuse at 1000ºC. Fine glass mixed with brick making clay can reduce the temperature during the brick making process, thus saving energy. The final product is a stronger, more resistant brick.

- **Ceramics (Decorative Glass)**

Pottery manufacturers use minerals such as feldspar as a fluxing agent to bind clay and other fillers during firing. Ground glass can be used to replace minerals containing oxides such as Na₂O and K₂O which make up 25% of the total product. These minerals are added as a fluxing agent. The ground glass can be used as a source of the above oxides.

- **Blast abrasives**

Blast cleaning involves firing a granular or powdered abrasive at a surface. Abrasives can be expandable or non-expandable, which can be reused. Non-expandable abrasives such as
alumina and silicon carbide, expandable abrasives sand, and copper slag are expensive materials. The use of sand has high health risks when used in dry blast situations since air borne crystalline silica can cause silicosis. Finely crushed glass can be used to replace blast abrasives. Glass contains less than 1% crystalline silica and has no known health and safety risks.

- **Filtration**

Crushed glass may be used as a granular material for water filtration applications such as the treatment of potable water, municipal waste water and industrial wastewater. Varying sizes of glass can be used in varying filtration applications: Glass particles between 0.5mm and 2 mm are acceptable for filtering potable water, up to 4.5 mm for filtering waste water.

- **Concrete aggregates**

The major problem with using glass in cement is that the alkali from cement can react with the silica in the glass (alkali-silica reaction ASR) to produce a gel on the surface that can lead to cracks in the concrete. This issue can be avoided by using a small size glass (less than 1mm) or by using low alkali cement.

Advantages of using glass in concrete applications:
- No water absorption therefore increased durability
- Improved concrete flow properties
- The finely ground glass has pozzolanic properties (increases the concrete strength)

Pioneer Road Services is working closely with City of Canning to find ways of using crushed glass at - 4mm in their concrete plant.

### 5. Strengths, Weaknesses & Lessons learned

- **Sales and Marketing**

With support of the Department of Environment through the Strategic Waste Initiative Scheme (SWIS), PRS has been able to purchase and install the GlassAgg plant. We have acknowledged their support in a recently prepared marketing brochure designed to promote Glass asphalt under the theme “Glass asphalt: a convenient truth”.

- **Market & Industry acceptance**

There has been extensive health and safety research conducted throughout the world on the effects of using recycled glass in asphalt mix. The risk is rated as low as given the outcomes and results from the technical trials and research information. PRS have decided to enclose the crusher with a structure which will add significant cost but should stop any airborne particles from presenting a nuisance. We expect to undertake this work in early 2010.

Initially Pioneer Road Services had numerous queries related to the quality of asphalt, the fatigue resistance, the effect of glass on car tyres, glare from the sun etc. Pioneer Road Services (PRS) held meetings with the construction managers and engineers from the local councils with which contracts were held. These councils included: Shire of Kalamunda, Town of Vincent and City of Canning. PRS has presented the glass mix research results and the advantages of using waste glass instead of disposing of this material to landfill. Currently the above councils are using 5% of glass in the asphalt produce for low and medium traffic roads.
The asphalt industry and local government authorities have become more comfortable with the notion of recycled glass in asphalt.

- Divert waste glass from landfill

From June 2009 until 30th of September Pioneer Road Services produced 20,000 tones of glass asphalt, diverting 1000 tones of waste glass from landfill.

- Market leaders

As far as we are aware, the glass crushing plant is the first plant in Australia able to crush glass to 3 mm all in size. This accomplishment allows Pioneer Roads Services in the near future to use glass in all asphalt produced for Local and State Government authorities.

- Completion date delayed.

The GlassAgg plant was unable to crush the glass down to 3 mm so the producer had to make modifications to suit PRS’ requirements. After installation it was noticed that the wear and tear of the plant required frequent change of screens and resulted in unanticipated costs and delays to production.

The plant was modified by Pioneer Road Services: a cone crusher was installed as a trial in order to produce glass at 3 mm all in size. With the input of additional funds, the crusher now operates without significant wear whilst achieving the designed output. Future modifications will allow coarser gradings which will improve asphalt characteristics but currently most customers prefer the finer glass.

- Variations to the costs:

Pioneer Road Services had to support the payment of approximate $33,000 for the changes made to the plant and the hire of a cone crusher for the trial (attached invoices). As the trial was successful Pioneer Road Services intends to purchase 2 cone crushers to use them simultaneously on the glass plant.

### GLASS CRUSHING PLANT - HAZELMERE

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>$</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CAPEX (ASSET 9913)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APPROVED CAPEX VALUE</td>
<td>384,000</td>
<td></td>
</tr>
<tr>
<td>COMPLETED CAPITAL COSTS</td>
<td>515,000</td>
<td></td>
</tr>
<tr>
<td>CAPITAL UNDER (OVER) SPEND</td>
<td>(131,000)</td>
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<tr>
<td><strong>GOVERNMENT GRANTS</strong></td>
<td></td>
<td></td>
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<tr>
<td>APPROVED GOVERNEMTN GRANT VALUE</td>
<td>150,000.00</td>
<td><strong>NB ARE INCLUDED IN TOYAL CAPITAL EXPENSE</strong></td>
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<td>GOVERNMENT GRANT PAYMENTS RECEIVED TO DATE</td>
<td>-139,500.00</td>
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<td>BALANCE OF GRANT FUNDING OUTSTANDING</td>
<td>10,500.00</td>
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<td><strong>RUNNING COSTS</strong></td>
<td>Unit rate</td>
<td></td>
</tr>
<tr>
<td>R&amp;M</td>
<td>1.5 $/tn</td>
<td>Waste glass delivered 15km to Hazelmere Plant</td>
</tr>
<tr>
<td>Cartage</td>
<td>$ 0.30/tn</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>$0.5/tn</td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td>$1/tn</td>
<td>Operator wages for processing glass</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$ 3.30/tn</strong></td>
<td></td>
</tr>
</tbody>
</table>
6. Future Goals

1. Finalize the marketing brochure for Glass asphalt. Invite Local and State Government road authorities for the official opening. If possible involve the Department of Environment and SMRC.

2. Develop new mix designs for various types of glass asphalt. The current designs incorporate 5-6% of glass in 7 and 10 mm Dense Grade Granite and Laterite mixes. We intend to increase the use of glass in 14 and 20 mm asphalt mixes and develop new mixes with 15-25% glass for intermediate or base course layers.

3. Acquire the glass from SMRC at no extra cost except cartage. The glass is contaminated with approximate 3-5% of paper and small plastic fragments.

4. Install 2 cone crushers to the plant and screen the glass to -3 mm all in.

5. Enclose the crusher within a structure to minimise dust impact from the crushing operation.

6. Use the glass purchased in all asphalt produced for Local Government contracts. Due to the changes in the crushing plant we are able to add glass to all suppliers, state, local government and private contractors.

7. Market the glass as a WA environmental initiative. Currently working on a brochure for “Glass asphalt: the convenient truth”. If possible involve Local and State Government authorities in the promotion of the use of waste glass in asphalt.

8. Develop and expand the business into more profitable areas. This initiative would make the glass crushing/screening plant self-reliant.