Maintenance interventions for surface friction

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1. SCOPE
   • The purpose of these trials was aimed at evaluating the effectiveness of several different
types of asphalt retexturing treatments and saw grooving
   • The cost effectiveness of each treatment was be assessed
   • The trials were intended to provide guidelines to the practical selection of available
processes intended for surface restoration treatments providing improvement of texture
and skid resistance and reduction of water film depth.

2. ROAD SURFACING REQUIREMENTS
   • Road surfacing deficiencies on the Queensland Transport and Main Roads Department
(QTMR), Brisbane Metropolitan Region network are required to be recorded under the
Routine Maintenance Performance Contract (RMPC)
   • Under the RMPC base level, routine maintenance is ongoing (i.e. – patching, profiling,
crack sealing, holding treatments), however asphalt overlays and pavement
rehabilitations are programmed when the pavement approaches unserviceable limits.
   • Road surfacings can differentially degrade due to traffic effects and exhibit deficiencies
over time through stone polishing, surface texture loss and skid resistance reduction.
   • Intervention levels for rutting are set in the RMPC (typically 35mm max). The levels of
skid resistance are set in the QTMR Skid Resistance Management Plan.(1)
   • QTMR Drainage Manual specifies desirable and maximum water film depths for road
surfaces (2.5mm < desirable max & < 5mm maximum during 50mm/hr rainfall events)
   • For new works proposed levels of surface texture and PAFV (polished aggregate friction
values) are currently being set by E&T Division of QTMR. (2)
3. ROAD SURFACING DEFICIENCIES

The most common defects that occur on asphalt surfacings within the Metropolitan Region are:

- Rutting
- Bleeding
- Flushing
- Stone polishing

In considering the loss of performance of the surfacing the following properties are evaluated:

- Texture depth
- Skid resistance

The initial assessment of these defect characteristics is made by tests for:

- Rutting – surface shape (geometrics, ride quality)
- Texture depth – Sand Patch or Laser Profilometer
- Skid resistance testing – standard equipment
- Free surface bitumen - visual

To maintain the network at acceptable levels, without exceeding current maintenance budget allocation, remedial treatments are required to reinstate the road surface shape, texture and skid resistance.

4. TREATMENT OPTIONS AVAILABLE

Increased texture depth and reduced aggregate polishing provide a significant contribution to increased skid resistance and reduced water film depth. These improvements form the basis of the following maintenance interventions:

1. Mechanical Abrasion (Micro-Retexturing)
2. Milling (Profiler)
3. Steel Shot blasting
4. Ultra high pressure water cutting
5. Saw grooving

5. RETEXTURING & GROOVING TRIALS

The site location for trials 1 to 4 was the Old Northern Road Everton Park (140/900/704), an overlay constructed November 2005. The site location for trial 5 was Centenary Highway, Jindalee off ramp (U18A) which as a 14mm Stone Mastic Asphalt surface (SMA 14mm).
Retexturing Trials
1. A program maintenance overlay project showed signs of premature distress following the onset of summer.
2. Site selection for trials 1 – 4 was based on surface deficiencies (flushing, rutting, loss of surface texture and skid resistance).
3. The overlay for trials 1 – 4 was dense graded asphalt (DG14 C320), investigations revealed that the mix design was not rut resistant. The mix design was withdrawn from service 2006 and intervention to reinstate skid resistance was programmed.

Grooving Trials
1. The selection of the site for saw grooving was driven by crash history during wet weather which required improved removal of surface water on the tight radius curve. The selection was also influenced by the high ongoing repair costs due to frequent guard rail (Minnesota Barrier) replacement (5 times per year) after wet weather.
2. Saw grooving treatment was selected as it effectively allows water to drain off asphalt surfaces preventing water ponding which may lead to aquaplaning
3. Internationally, airports commonly use saw grooving for this purpose
4. The equipment & experience was available from a contractor who had worked previously on NZ Transit projects.

Trial treatment processes used:
1. Trial 1: Micro retexturing (Pavement Treatments Australia)
2. Trail 2: Profiling – fine cut (RPQ)
3. Trial 3: Steel shot blasting (Multitech Blastrac)
4. Trial 4: Ultra high pressure water cutter (Fulton Hogan)
5. Trial 5: Saw grooving (Fulton Hogan)
### Table 1: TRIAL DETAILS

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Trial 1: Micro retexturing</th>
<th>Trial 2: Profiling fine cut</th>
<th>Trial 3: Steel shot blasting</th>
<th>Trial 4: Ultra high pressure water cutter</th>
<th>Trial 5: Saw grooving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane Direction</td>
<td>North</td>
<td>South</td>
<td>North</td>
<td>North</td>
<td>North</td>
</tr>
<tr>
<td>Lane Treated</td>
<td>2 lanes full width</td>
<td>2 lanes full width</td>
<td>Left lane full width</td>
<td>Left lane full width</td>
<td>Off ramp, single lane only</td>
</tr>
</tbody>
</table>

### 6. SURFACE TEXTURE

Texture depth measurement was performed before and after treatment using either the Sand patch test (Austroads method AG:PT/250) or the Laser Profilometer. In the case of saw grooving, texture depth was not performed as this test it was not considered indicative of the reduction in water film depth.

### Table 2: TEXTURE DEPTH RESULTS

<table>
<thead>
<tr>
<th>Trial</th>
<th>Mean (mm)</th>
<th>Trial 1: Micro retexturing</th>
<th>Trial 2: Profiling fine cut</th>
<th>Trial 3: Steel shot blasting</th>
<th>Trial 4: Ultra high pressure water cutter</th>
<th>Trial 5: Saw grooving</th>
</tr>
</thead>
<tbody>
<tr>
<td>IWP</td>
<td>Before</td>
<td>0.41</td>
<td>0.36</td>
<td>0.22</td>
<td>0.32</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0.48</td>
<td>1.62</td>
<td>0.59</td>
<td>0.51</td>
<td>n/a</td>
</tr>
<tr>
<td>BWP</td>
<td>Before</td>
<td>0.60</td>
<td>0.44</td>
<td>0.68</td>
<td>0.63</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0.59</td>
<td>1.75</td>
<td>n/a</td>
<td>0.80</td>
<td>n/a</td>
</tr>
<tr>
<td>OWP</td>
<td>Before</td>
<td>0.39</td>
<td>0.36</td>
<td>0.17</td>
<td>0.24</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0.49</td>
<td>1.72</td>
<td>0.55</td>
<td>0.46</td>
<td>n/a</td>
</tr>
</tbody>
</table>

### Table 3: TEXTURE DEPTH IMPROVEMENT

<table>
<thead>
<tr>
<th>Trial</th>
<th>Mean Increase (mm)</th>
<th>Trial 1: Micro retexturing</th>
<th>Trial 2: Profiling fine cut</th>
<th>Trial 3: Steel shot blasting</th>
<th>Trial 4: Ultra high pressure water cutter</th>
<th>Trial 5: Saw grooving</th>
</tr>
</thead>
<tbody>
<tr>
<td>IWP</td>
<td>0.07</td>
<td>1.26</td>
<td>0.37</td>
<td>0.19</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>BWP</td>
<td>0.0</td>
<td>1.31</td>
<td>n/a</td>
<td>0.17</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>OWP</td>
<td>0.10</td>
<td>1.36</td>
<td>0.38</td>
<td>0.22</td>
<td>n/a</td>
<td></td>
</tr>
</tbody>
</table>

From the preceding data it appears possible to improve the macro texture significantly (1.3mm increase) using fine milling process (trial 2). The other treatments (trails 1, 3, 4) provide increasing texture from 0.1mm to 0.4mm.

Using these techniques it should be possible to improve the surface texture of a deficient surface to an acceptable level above the proposed minimum requirement. (Figure 5) For a new asphalt surface the proposed QTMR minimum texture depth requirement is 0.4mm for speed limit of < 80km/hr and 1.1mm for >80km/hr.
7. SKID RESISTANCE

The initial skid resistance testing of the overlay for trial site 1 – 4 indicated that it was approaching the minimum investigatory level of the QTMR Skid Resistance Management Plan.\(^{(1)}\)

It was considered that the trials would restore an acceptable level of skid resistance mitigating the need to resurface the pavement.

Skid resistance testing was then undertaken by the Department’s Pavements Testing Services Branch using the Norsemeter (ROAR) and returning measurements in International Friction Index values (IFI).

The skid resistance measurements are typically illustrated in Figures 6 for the trials sites.

On the trial site selected (trials 1 - 4), further loss of skid resistance occurred under traffic due to the soft and unstable nature of the asphalt. This affected the economic evaluation of the treatments over the longer term.

It was consider that the skid resistance of the saw grooving trial 5 was not the prime basis of improvement in the road surface due to the low speed of traffic and the primary accident cause being water depth. However a skid resistance test was performed after the treatment which indicated satisfactory skid resistance levels and differentiated between transverse and longitudinal saw grooves. Due to the tightness of the curve the skid resistance measurement becomes difficult to implement. This trial did not provide sufficient information to draw a comparative position on saw treatments versus the other options w.r.t. skid resistance.
Figure 6: Skid Resistance Measurements of Trials 1 to 5 sites to late 2007
8. GUIDE TO SELECTION OF TREATMENTS

Treatment costs are compared in the below table based on the trials costs only. Additional costs were incurred for site supervision, quality control, testing, traffic control and clean-up / waste disposal, all are time dependant and affect each treatment’s overall costs differently.

Table 4: COMPARATIVE TREATMENT COSTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Trial 1 Micro retexturing</th>
<th>Trial 2 Profiling fine cut</th>
<th>Trial 3 Steel shot blasting</th>
<th>Trial 4 Ultra high pressure water cutter</th>
<th>Trial 5 Saw Grooving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Rate</td>
<td>$4/m²</td>
<td>$10/m²</td>
<td>$5/m²</td>
<td>$6.5/m²</td>
<td>$19.5/m²</td>
</tr>
<tr>
<td>Suction Broom</td>
<td>QTMR provided</td>
<td>QTMR provided</td>
<td>QTMR provided – not used</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Traffic Control</td>
<td>QTMR provided</td>
<td>QTMR provided</td>
<td>QTMR provided</td>
<td>QTMR provided</td>
<td>QTMR provided</td>
</tr>
<tr>
<td>Supervisory Quality Ass</td>
<td>QTMR provided</td>
<td>QTMR provided</td>
<td>QTMR provided</td>
<td>QTMR provided</td>
<td>QTMR provided</td>
</tr>
</tbody>
</table>

Table 5: PRODUCTIVITY – RATE OF TREATMENT

<table>
<thead>
<tr>
<th>Treatment Details</th>
<th>Trial 1 Micro retexturing</th>
<th>Trial 2 Profiling fine cut</th>
<th>Trial 3 Steel shot blasting</th>
<th>Trial 4 Ultra high pressure water cutter</th>
<th>Trial 5 Saw Cutting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (m)</td>
<td>163</td>
<td>160</td>
<td>230</td>
<td>203</td>
<td>80</td>
</tr>
<tr>
<td>Width (m)</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>11</td>
</tr>
<tr>
<td>Area (m²)</td>
<td>570</td>
<td>560</td>
<td>805</td>
<td>805</td>
<td>880</td>
</tr>
<tr>
<td>Time (mins)</td>
<td>60</td>
<td>67</td>
<td>65</td>
<td>210</td>
<td>960</td>
</tr>
<tr>
<td>Rate of treatment (m²/hr)</td>
<td>570</td>
<td>500*</td>
<td>740</td>
<td>230</td>
<td>55</td>
</tr>
<tr>
<td>Achieved on later projects (m²/hr)</td>
<td>Not further used</td>
<td>Up to 625*</td>
<td>Over 800</td>
<td>Up to 300</td>
<td>Up to 140</td>
</tr>
</tbody>
</table>

Note * for fine milling the depth of cut affects productivity which for 35 mm rut removal would limit the rate of treatment to no higher than 500 m²/hr

Table 6: TREATMENT EFFECTIVENESS

<table>
<thead>
<tr>
<th>Surface Deficiency</th>
<th>Trial 1 Micro retexturing</th>
<th>Trial 2 Profiling fine cut</th>
<th>Trial 3 Steel shot blasting</th>
<th>Trial 4 Ultra high pressure water cutter</th>
<th>Trial 5 Saw Grooving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skid Resistance</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+?</td>
</tr>
<tr>
<td>Rutting</td>
<td>-</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flushed Surface (loss of texture)</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Bleeding (free bitumen on surface)</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Polished aggregate</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>Water film</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>++</td>
</tr>
</tbody>
</table>

Rating scale

- highly effective ++
- effective +
- not effective -
- unclear ?

Maintenance interventions for surface friction
8.1 Limitations of treatments

- During treatment as road temperature increases trials 1 and 3’s effectiveness and productivity will be decreased, particularly on fresh asphalt. 
  Recommendation: Avoid their use during day time in summer, suitable at night.
- Bleeding surface – trials 1,3 and 5 were unable to effectively remove the free binder. 
  Recommendation: use trial 4 equipment
- Free bitumen on surface and flushed / bleeding seals require specific treatments 
  Recommendation: use trial 4 equipment
- Pavement layer thickness – profiling removes layer thickness which will affect the integrity, increase the potential for delamination and limit the ability to repeat treatment. 
  Recommendation: use trial 2 equipment when layer thickness is a adequate

8.2 Other considerations

- Cost of waste management & disposal should be included in evaluation
- Cleanliness of the process impacts on the public
- Retreatment may be necessary on tender asphalt and polishing due to high traffic
- Productivity effects the economics of addition hourly rate services (traffic control, QA, supervision etc)
- Speed and traffic environment require specific outcomes for texture depth and skid resistance which will impact on the available treatment options
- The need for prequalification of contractors – consider subcontracts for treatment service
- Performance monitoring is required due to limited experience to date
- Evaluation of long term treatment effectiveness needs to be funded
- Treatment costs should be compared to available conventional treatments (Tables 7 & 8)

<table>
<thead>
<tr>
<th>Table 7: COMPARATIVE TREATMENT COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>Unit Rate</td>
</tr>
</tbody>
</table>

Note: Above costs are indicative only, and exclude traffic control, supervision, QA for areas < 1000 m²

<table>
<thead>
<tr>
<th>Table 8: CONVENTIONAL TREATMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>Unit Rate</td>
</tr>
</tbody>
</table>

Note: Above costs are indicative only, and exclude traffic control, supervision, QA, etc

8.3 General Observation

The Metropolitan Region’s experience has included the use of specialised products, seals and asphalt overlays to address the defects in surface friction which is reflected in Table 8. These are considered as conventional treatment solutions for the surfacing defects in Table 6.

Table 7 provides an estimate of Comparative Treatments costs which could be utilised individually or in combination to provide improved surface friction properties. Any cost comparison should consider the expected performance life of these treatments against the effective life of those in Table 8.
9. CONCLUSION
Based on the experience from the trials reflected in this paper, there are grounds for the extended uptake of the remedial treatment options available to address the loss of surface friction. The trials have shown the ability of these options to economically extend the performance and serviceable life of the road surfacing when compared to more conventional treatments.

To gain enhanced understanding of the benefit derived, further monitoring of the treatments should be undertaken leading to their inclusion in the overall asset management strategy and options for maintenance treatments to reinstate surface friction characteristics.

10. REFERENCES
1. Queensland Transport and Main Roads, Skid Resistance Management Plan
2. Queensland Transport and Main Roads, Surface Texture Depth and Aggregate Polishing Resistance for Road Surfacings – Development of Interim Standards
3. Austroads, Guidelines for the Management of Road Surface Skid Resistance
4. NSW Roads and Traffic Authority, Retexturing of Asphalt and Concrete Surfaces by Pavement Treatments and Multitech, May 2009

11. ACKNOWLEDGMENTS
The author would like to thank the Queensland Transport and Main Roads Department for providing access to the trial details and the thank the following for their participation and contribution to the trials:

1. Metropolitan Region (Assets / Operations)
   • Andrew Nguyen – Principal Engineer (Asset Preservation)
   • Wade Mengel – Senior Engineer (Asset Preservation)
   • Michael Hook – Inspector Asphalt Contracts
   • Daniel Hafemeister – Inspector Construction
   • Scott Dight – Senior Inspector Maintenance

2. RoadTek
   • Ed Baran – Principal Engineer (Pavement Testing Services)
   • RoadTek – Asset Services – Traffic Management

3. Contractors
   • Roland Barwin – Pavement Treatments Australia
   • Tony Wehl – Road Profiling Queensland (RPQ)
   • Wayne Smith - Multitech Roads - Blastrac
   • Craig Vergelius – UHP Water cutter contractor Fulton Hogan
   • Peter Pezet – Saw cutting contractor – Fulton Hogan

4. Roads and Traffic Authority – New South Wales
   • David Smith – Asphalt Operations