SUMMARY REPORT ON TRIALS OF BITUMEN SPRAY SEALS ON BTB AT NANANGO

Field Report No.: 12
Date: April, 1999
SUMMARY REPORT ON SPRAY SEAL TRIALS ON BTB AT NANANGO

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SUMMARY REPORT ON SPRAY SEAL TRIALS ON BTB AT NANANGO

1 PURPOSE OF THE TRIALS

Following some concerns with the initial bitumen seals over the BTB, a series of trials were carried out to determine the most satisfactory seal type and application rates.

2 AIMS OF A SPRAY SEAL ON BTB

2.1 To protect the BTB base against ravelling.
2.2 To provide a satisfactory running surface.
2.3 To provide acceptable durability.
2.4 To waterproof the BTB base.

3 INITIAL SEALS

3.1 Observations

(a) Aggregate loss from the surface
   - At intersections and entrances where trucks are turning.
   - Where vehicles have braked heavily.
(b) The seal condition shows
   - There is not enough binder to hold the aggregate.
   - There is a poor aggregate cover.

3.2 Comments

(a) The stone on the 14 mm seal is very proud. The binder probably only covers the bottom 10-20%.
(b) The binder appears to be a bit on the soft side and the aggregate can be pulled out relatively easily. This may also be due to the lack of binder as the bitumen adheres to both the BTB and the aggregate. The effect of precoat condition is not known.
(c) The 14 mm aggregate is “large”, is single sized and has a good cubical shape.
(d) There are a lot of “windows”.
(e) There are sections of light and “dark” aggregate. Some aggregate has been rolled over and the dark colour is from the binder on the original bottom of the aggregate.
(f) There is no “tide mark” on the aggregate.
(g) There is no visible evidence of precoat on the stone.
(h) The BTB base presents a very hard surface.
(i) The 10 mm seal on the shoulder is in much better condition. The aggregate cover is very tight and individual particles are hard to pull out.
(j) See Appendix A for photographs.
3.3 Seal Design

(a) The seal design sheets show
   - Aggregate ALD of 8.5 mm
   - Aggregate spread rate of 120
   - Bitumen application rate of 1.25 l/m\(^2\) of C170
   - The seal design is based on:
     - AADT 1500 – 2500; 15-30% CV; fast moving vehicles
     - Voids factor 0.13
     - Adjustment for traffic and grades 0
     - Base application rate 1.105
     - Adjustment for embedment 0; existing surface 0
     - Sand patch results of 0.9 and 0.4 for extremes of BTB
       indicating a surface texture constant of +0.2 and −0.1 for
       a smooth or black seal
     - Ball penetration test of 7.4 and 8.0
     - Surface texture smooth and black

(b) See Appendix B for suggested revised design with a binder application rate of 1.75 l/m\(^2\) and an aggregate application rate of 1/95 m\(^3\)/m\(^2\) for the 14 mm seal (compared to 1.25 l/m\(^2\) and 1/120 m\(^3\)/m\(^2\) above).

(c) Conclusions

   - Use of an aggregate application rate of 1/120 m\(^3\)/m\(^2\) instead of 1/80 results in voids filled of 25% instead of 65%.

   - As the binder should come up to 2/3 to 2/3 (at least 50%) of the height of the aggregate, there is insufficient binder (or aggregate) to ensure good embedment with the binder application rate used.

   - The situation will be worse if the traffic is lower.

   - When using lighter aggregate application rates, the binder application rate should be significantly higher – say 0.25 to 0.30 l/m2 for an intermediate aggregate application rate.

3.4 Questions

(a) Was there enough binder in the first place?
(b) Was the binder on grade?
(c) Did the precoat affect the binder?
(d) Has any of the binder subsequently migrated into the BTB?
(e) Was the aggregate cover sufficient?
(f) Effectiveness of sand patch test?
(g) Effect of very hard, rough surface of BTB?
(h) Effect of brooming versus sand patch in terms of binder allowance?
3.5 **Possible Solutions**

(a) Increase aggregate application rate  
(b) Adjust binder rate to allow for light aggregate cover  
(c) Adjust binder rate to allow for binder absorption into BTB  
(d) Use of alternative binders - eg PMB  
(e) Prior treatment of BTB to seal off pores in BTB  
   - Light prime  
   - Dilute emulsion plus sand or grit  
   - Maybe water plus sand as part of laying BTB process  
   - 7 mm bitumen seal  
(f) Denser BTB surface – difficult / not desirable

3.6 **Recommended Trials (or combinations thereof)**

(a) Increased binder application rates to allow for light aggregate cover  
(b) Increased binder application rates to allow for absorption into BTB  
(c) Increased aggregate application rates to reduce “windows” and allow binder to rise up the stone  
(d) Use of alternative binders to increase adhesion and toughness and/or to reduce absorption into BTB  
(e) Seal surface pores in BTB  
   - Prime  
   - Application of dilute emulsion and sand or grit  
   - Application of water and sand or grit

4 **TRIALS ON 10-11/3/99**

4.1 **Aim of the Trials**

To find a satisfactory seal treatment

(a) over the BTB base  
(b) for remedial work on the existing 14 mm seal over the BTB

4.2 **Trial Details**

(a) On New Work  
   - C 170 at higher spray and aggregate application rates  
   - 7 mm seal  
   - Emulsion and sand treatment prior to 14 mm seal  
   - 14 mm seal using PMB in lieu of C 170

(b) On Remedial work  
   - 10 mm seal  
   - emulsion fog seal

(c) See Appendix D for locations
4.3 **Observations of Trials after 2 ½ months Trafficking**

See Table 1 and photographs in Appendix E.

4.4 **Summary of Trial Results**

(a) The use of a 7-mm seal on the BTB appears to be the most successful to date. This may require a 14 or 10 mm reseal in 7 to 10 years.

(b) The use of a 14-mm seal at the application rates on Trial 6 (C 170 at 1.8 l/m2 and 14-mm aggregate at 1/85) is the second best. It is a substantial improvement over the earlier seals, but has a few blemishes. If used, an increase in binder to 1.9 or even 2.0 l/m2 could be an advantage.

(c) There appears to be no advantage in using the Olexobit binder in lieu of C 170 bitumen for the 14 mm seal

(d) The emulsion / sand seal presents an even, non-textured surface suitable for sealing.

(e) Stripping has occurred on all the 14 mm seals to a greater or lesser extent. Where it occurs, it is located
   (i) along the centreline (crown, join in seal)
   (ii) between the wheel paths
   (iii) where truck brakes have locked up

(f) It appears that unless there is very good aggregate cover and interlock, the stones on the smooth, hard surfaces such as the BTB are relatively easily "rolled"out.

(g) The 7-mm aggregate was not precoated (and isn't stripping) while the 14 and 10 mm aggregates were precoated.

(h) Both the 10 mm reseal and the bitumen enrichment treatment appear to provide satisfactory treatments on the existing 14 mm seals. The 10 mm being the better option.

**NOTE:** None of the trials involved intersections or turnouts and it is not known how these seals would perform under screwing traffic. (There was a small turnout on the 7-mm trial at the entrance to a farm property)

4.5 **Other Comments**

(a) The surface texture of the BTB is variable, but no more than would be expected from this type of mix. The surface texture varies from some surface voids, to a tight, dense finish to individual large stones. This could have an influence on the variability of both the amount of seal binder absorbed into the BTB and the degree of initial and subsequent aggregate embedment.

(b) It appears as if there could be some migration of the binder into the BTB over a period of time.

(c) Where the aggregate has stripped, the surface is hard and smooth.

(d) There is some minor embedment into the BTB in the wheel paths.
(e) Aggregate size

-The 10-mm has used for the reseals and over the asphalt correction course while 14-mm was used on the BTB. Perhaps they should be the same?
-The 7-mm is performing better than the 14 mm on the BTB - Why? No precoat, tight aggregate cover, more flaky, reflects more light and hence lower surface temperature??
- The 14-mm aggregate could be too big (rolling out) on the smooth, hard surfaces. Again, a 10 mm would be more suitable.

4.6 Aggregate Precoating

(a) The precoating process at Nanango Quarry has been less than satisfactory. It involves passing the aggregate over a screen and at the same time three rows of water sprays “saturate” the aggregate which then passes up a belt to a header box where the precoat is applied. The equipment is fairly standard, but there have been problems on occasions with dirty aggregate, too much water and/or too much precoat.

(b) It was reported that when left to dry in the stockpile for sufficient time, the precoated aggregate appeared to be satisfactory.

(c) A successful trial using a revised precoating procedure has been carried out. It involved screening and washing the aggregate, allowing the aggregate to drain/dry out in the stockpile and then lightly dampening the aggregate and precoating it with the correct amount of precoat.

The precoating agent formula has also been modified to increase the concentration of active amine.

4.7 Possible Binder Absorption into BTB

(a) Allowance assumed for trial 14 mm seal design – 0.2 l/m2

(b) Emulsion / Sand Seal Trial Section

Application rate = 0.5 l/m2 of 80:20 emulsion/water.
Residual Bitumen = 0.5 x 0.8 x 0.6 = 0.24 l/m2
Not all of the binder has been absorbed – in practice, there seems to be a reasonable coverage on the surface.

(c) Conclusion – there is not an excessive amount of bitumen absorbed into the BTB.
<table>
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<tr>
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<td>APPLIC l/m²</td>
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**TABLE 1** DETAILS AND OBSERVATIONS OF SEAL TRIALS ON BTB (See Appendix D for locations and Appendix E for Photographs)
4.8 Causes of Problems / Remedies

(a) "Traditional" Causes

- Low binder content
- Poor stone adhesion – dirty, hydrophilic, wet, incorrect precoating
- Absorption of binder
- Inadequate rolling prior to opening to traffic

(b) It appears that:

- The use of heavier binder and aggregate application rates over the BTB substantially improve the chances of success
- The use of 7 mm aggregate improves chances of success over the BTB

4.9 OPTIONS

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<thead>
<tr>
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<td>ONE COAT SEAL NOW</td>
<td>No more delays</td>
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<tr>
<td>7 mm seal</td>
<td>MRD Acceptance</td>
</tr>
<tr>
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<td>Cost responsibility and timing of subsequent 14 or 10 mm seal</td>
</tr>
<tr>
<td></td>
<td>Based on these trials, this seems to be the least risk solution</td>
</tr>
<tr>
<td>10 mm seal at appropriate application rates</td>
<td>Given the performance of the 7 mm, the use of 10 mm would seem a reasonable solution</td>
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<tr>
<td></td>
<td>Treatment at turnouts?</td>
</tr>
<tr>
<td>Any of above with Wondai aggregate</td>
<td>If aggregate is the problem, this may solve most of the problems, provided correct application rates are used</td>
</tr>
<tr>
<td>TWO COAT TREATMENT NOW</td>
<td>Costs</td>
</tr>
<tr>
<td>7 mm + 10 or 14 mm</td>
<td>Should work well</td>
</tr>
<tr>
<td>Emulsion/sand + 10 or 14 mm</td>
<td>Should prevent or minimise any binder absorption</td>
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<tr>
<td>FURTHER TRIALS</td>
<td>Delays to contract</td>
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<td></td>
<td>Possibility of sealing in cold weather</td>
</tr>
<tr>
<td></td>
<td>Risk of structural damage from water due to delayed sealing</td>
</tr>
<tr>
<td></td>
<td>Possibly more confidence in treatment</td>
</tr>
<tr>
<td></td>
<td>Possibility of discovering real reason for problems</td>
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</table>

TABLE 2 POSSIBLE OPTIONS
5 FURTHER TRIALS ON 20/3/99

5.1 Aim of the Trials

To assess the suitability of seals using 10 mm aggregate. The trials were carried out over both BTB and BTB previously treated with emulsion and sand.

5.2 Trial Details

The location of the trials are shown in Appendix F.

(a) On BTB

- Class 170 bitumen at 1.5 l/m² and 10 mm precoated aggregate at 1/140 m³/m² (actual 1/132)
- Class 170 bitumen at 1.5 l/m² and 10 mm precoated aggregate at 1/160 and 1/180

(b) On BTB previously sealed with emulsion and sand on 22/12/98

- Class 170 bitumen at 1.2 l/m² and 10 mm precoated aggregate at 1/140 (actual 1/137)
- Class 170 bitumen at 1.2 l/m² and 10 mm precoated aggregate at 1/160 and 1/180

5.3 Observations

(a) Over BTB

- Run 1 at 1/132 was slightly heavier than the aim of 1/140, and there appeared to be a lot of loose stone on the surface and not in contact with the bitumen.
- Runs 2 and 3 at 1/180 and 1/160 appeared too light and there was the possibility of flushing, especially in the 1/180 area.
- At 1.5 l/m² it was estimated that about 50% of the stone was embedded into the bitumen, but it was difficult to estimate on Run 1 because of the heavy stone application.

(b) Over the BTB treated with emulsion and sand

- Run 1 at 1/137 appeared to have excessive quantities of loose stone on the surface. The bitumen was about 50% of the way up the stone.
- Runs 2 and 3 appeared visually similar to Runs 2 and 3 on the BTB.

5.4 Summary

The two Run 1s appear to be the best solution.
6 RECOMMENDATIONS

6.1 The carried out using 10 mm precoated aggregate have been undertaken and are performing well to date. It would appear that the earlier problems experienced with the 14 mm spray seal were a combination of factors including:

- Low binder application rates (exacerbated by some absorption of binder into the BTB layer)
- Lighter aggregate application rates resulting in higher voids in the spray seal surface
- Some questions over aggregate quality and moisture content and the precoating process

6.2 Given the above, the 10 mm seal should provide the optimum solution and meet the criteria required for sealing of the BTB.

6.3 Recommendations:

- Application rates of 1.5 l/m² for bitumen and 1m³ /140 m² for aggregate (subject to aggregate ALD).
- Elimination of variable quality material and monitoring of aggregate cleanliness and moisture content
- Monitoring of the precoating process

6.4 Correction course

Review application rates with correct ALD.

6.5 Intersections

May need to consider the use if a racking-in coat of small aggregate or a two coat seal.

Spray Seal trials Summary Report
PHOTOS OF INSPECTION 10/12/98

1 General View of Sealed Section of BTB

2 Close up of Spray Seal Surface

3 View of BTB Surface

APPENDIX A

FR12 BTB at NANANGO
APPENDIX B

DESIGN FOR 14 mm SEAL ON BTB

The following is based on the current AUSTROADS design and other discussions.

1 AGGREGATE SPREAD RATES

The ideal spread rate is said to be 900/ALD. This rate can be approached by use of a well-operated mechanised spreader. The aim therefore should be 800/ALD, although a rate of 666/ALD may be required in some cases.

Queensland Transport consider that 1000/ALD should be used as this eliminates flushing (not surprisingly) and aggregate whipoff. However, others believe this is not the way to go.

Spread Rates for ALD = 8.5 mm

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<tr>
<td>1</td>
<td>1/94</td>
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<td>1/106</td>
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Starting point should be 1/95

2 BINDER APPLICATION RATE

Data given:

Traffic AADT = 1500 – 2500
Commercial Vehicles = 15-30%
Sand Patch = 0.4 and 0.9 mm
Ball penetration = 7.4 and 8.0 mm (seems high?)

Traffic: assuming this is both ways then vehicles per lane per day = 750-1250

Design:

Basic Voids - Vehicle/lane/day = 600-1200
\[ V = 0.13 - 0.15 \text{ - Midpoint} \]
Adjustments to V
\[ \text{Aggregate shape/size} + 0.02 \]
\[ \text{Traffic} - 0.01 \]
\[ 0.15 \]

Basic Application Rate = 0.15 x ALD
= 0.15 x 8.5
= 0.15 x ALD
= 0.15 x 8.5
= 1.275
= 0.25

Surface Texture
Embedment (0.2 but take 0.1 as Ball test seems too high)
\[ - 0.10 \]
Absorption
Aggregate + 0.05
Into BTB (0.2 to 0.3) + 0.25
1.725

3 SUMMARY

Aggregate 1/95
Binder 1.75 l/m²
## LAYOUT OF SPRAY SEAL TRIALS ON 22/12/98

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<tr>
<td>(10mm 1/132 m³/m²</td>
<td>Test 2B</td>
<td>(11)</td>
<td>Test 2B</td>
<td>(11)</td>
<td></td>
</tr>
<tr>
<td>Test 1B</td>
<td>(13)</td>
<td></td>
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<table>
<thead>
<tr>
<th>C170</th>
<th>Emulsion</th>
<th>C170</th>
<th>Emulsion</th>
<th>C170</th>
<th>Emulsion</th>
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<tbody>
<tr>
<td>0.5% Syntol TX</td>
<td>0.5% Syntol TX</td>
<td>0.5% Syntol TX</td>
<td>0.5% Syntol TX</td>
<td>0.5% Syntol TX</td>
<td>0.5% Syntol TX</td>
</tr>
<tr>
<td>1.11 l/m²</td>
<td>0.36 l/m²</td>
<td>No Cover</td>
<td>0.36 l/m²</td>
<td>No Cover</td>
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</tr>
<tr>
<td>(10mm 1/132 m³/m²</td>
<td>(14)</td>
<td></td>
<td>(14)</td>
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</tr>
</tbody>
</table>

_Spray Seal trials Summary Report_
A3. C170 2 1/m² - 14 mm 1/120 m³/m²

A6. C170 1.8 l/m² - 14 mm 1/85 m³/m²
A9. C170 - 1.1 l/m² - 7 mm 1/142 m³/m²

Wheel Path

Between Wheel Paths
A7. EMULSION 0.5 l/m² - SAND TREATMENT ON BTB

Wheel Path

Centre of Wheel Path
B. REMEDIAL TRIALS OVER 14 mm SEAL ON 40C NANANGO - YARRAMAN

B11/12. EMULSION FOG SEAL - NO SAND

Looks OK - Still Hungry But Holding

B13/14. C170 1.1 l/m² - 10 mm 1/132 m³/m²

Looks Good
### LAYOUT OF ADDITIONAL SPRAY SEAL TRIALS on 20/3/99

**Road 41A**

<table>
<thead>
<tr>
<th>Trial 2 – Over BTB with emulsion and sand</th>
<th>Trial 1 – Over BTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run 1</td>
<td></td>
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<tr>
<td>South (to Nanango)</td>
<td></td>
</tr>
<tr>
<td>1.2 l/m² and 1/137 m³/m²</td>
<td>1.2 l/m² and 1m³/1m²</td>
</tr>
<tr>
<td>Run 2</td>
<td></td>
</tr>
<tr>
<td>North (to Goomeri)</td>
<td></td>
</tr>
<tr>
<td>1.3 l/m² and 1/160 m³/m²</td>
<td>1.2 l/m² and 1m³/1m²</td>
</tr>
<tr>
<td>Run 3</td>
<td></td>
</tr>
</tbody>
</table>
| Ch 19939                                | Ch 19899         | Ch 19800