Study Tour 2011

South Africa & CAPSA’11
Cape Town, Stellenbosch, Pretoria, Durban, KNP

3rd to 19th September 2011

GROUP REPORT
V3
Australian Asphalt Pavement Association
Study Tour 2011 – South Africa & CAPSA’11
Group Report

Issued by:

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1. EXECUTIVE SUMMARY

Overview of study tours undertaken previously by AAPA and the typical objectives and participants.

AAPA 2011 Study Tour to South Africa and the CAPSA’11 Conference

Topics, places visited and overall objectives:

Hosts with names and places visited.

The Key topics were:

- Surface Treatments
- Binders
- Improving pavement performance
- Sustainability
- General

This AAPA 2011 Study Tour Group Report answers the questions raised in detail, includes observations on the topics and makes recommendations for actions to benefit Australia. The recommendations are highlighted as follows:

Surface Treatments

Key recommendations and actions extracted from the detailed report in the chapter

Binders

Key recommendations and actions extracted from the detailed report in the chapter

Improving pavement performance
Key recommendations and actions extracted from the detailed report in the chapter

Sustainability
Key recommendations and actions extracted from the detailed report in the chapter

General Issues
Key recommendations and actions extracted from the detailed report in the chapter

Summary
The short 3 to 19 September 2011 study tour provided the 9 participants with an opportunity to directly address relevant Australian issues and to provide a joint feedback on the status in South Africa on key topics of significant relevance to Australia. Apart from the contacts made in the South Africa, the participants have established good working relationships which will benefit the roads sector into the future.

The recommendations provide a path for the roads industry to move forward gaining benefit from the knowledge and understanding developed during the study tour.

Thanks & acknowledgements
The tour party extends its thanks to the Australian Asphalt Pavement Association Board and CEO for their support and facilitation of the tour including the partial sponsorship of some of the participants. The wonderful support, transport arrangements and fellowship given to us by our South African hosts, all the presenters and their support staff is acknowledged with great thanks. Without the organization and commitment of our hosts, the tour and the important learnings and recommendations that have arisen, would not have been possible.
2. INTRODUCTION

In the forty year history of the Australian Asphalt Pavement Association, a number of overseas study tours have taken place to facilitate a framework to learn from best practices and to ensure Australia has the opportunity to observe and implement world class technologies in highway engineering.

Suitable picture with group at facility

This report summarises the observations and combined feedback of the personnel who participated in the study tour of the South Africa in September 2011. Prior to embarking on the tour, four topics of current interest to the Australian paving Industry were identified and for each of these South African experience and perspective would be sought. The topics were:

- Surface Treatments
- Binders
- Improving pavement performance
- Sustainability
- General

Chapter 3 of the report provides a concise overview of the observations for each topic and offers recommendations for actions that could be pursued in Australia following the tour. Chapters 4 to 8 provide greater detail of the engagements with the South Africans on each topic.

Chapter 9 contains a list of appendices covering the itinerary of the tour, the participants, the questions posed and a list of useful acronyms and abbreviations. The final appendix is a list of the 178 presentations, handouts and references presented during the tour. The electronic version of the report provides links to some of the referenced material.

Photographs of the tour visit can be obtained from: Tour Photos
3. OVERVIEW AND RECOMMENDATIONS

3.1 Surface Treatments

Observations
1. Sprayed seals are used extensively under wide range conditions including heavily trafficked roads. Under these conditions Crumb Rubber binders have provided an increase in service life over other modified binders.
2. Periodic maintenance (sealing, slurry) is scheduled as a preventative maintenance treatment rather then applied on a worst first basis
3. Rejuvenation is a widely accepted practice that can extend the life of seal by 3 – 4 years
4. Triple seals and sand seals could prove useful in specific situations that currently are not catered for.

Recommendations
1. Provide guidance and assess risks on the use of spray seals under heavy traffic for reseals and new works
2. Trial South African spray seal configurations and aggregate spread rates
3. Investigate why the use of rejuvenation seals has decreased and reasons for this should be investigated and means to overcome any issues considered
4. Provide input on South African asset management practice into Austroads project AT1536
   Good practice in reseal programming

3.2 Binders

Observations
1. Bitumen supply constraints will support importation with consideration being given to performance based testing and specifications
2. Use of wet blend field blended crumb rubber bitumen in seals and asphalt
3. Use of polymer modified bitumen emulsions to extend sealing season

Recommendations
1. Increase the use of field blended CRB for spray seals and wet blend CRB for asphalt wearing courses
2. Use PME’s for constructing seals in winter based on TG1 specifications
3. Make use of dilute emulsion for cover sprays
3. Overview and Recommendations

4. Make greater use of rejuvenation treatments to extend the life of existing aged seals

5. Improved binder handling and test methods
   a. High speed mixing blenders and digestion tanks with augers for producing CRB
   b. Use the Dynamic Shear Rheometer (DSR) to develop performance based specifications for binders across the temperature spectrum
   c. Use of TG1 storage stability test to measure segregation of PMBs
   d. On-site measurement of CRB using a hand held viscometer to check compliance before use

3.3 Improving pavement performance

Observations

1. SAPDM - The improved South African Pavement Design System will provide a holistic comprehensive design system for surfacing and pavement layers embracing material properties, measured performance, proven experience and variable loading conditions.

2. Funding of pavement Maintenance - Based on previously poor funding provision, road maintenance funds are now ring-fenced and locked-down in funding allocations. Formal maintenance management systems are required to measure and manage the network condition and motivate funding requests.

3. Pavement and asset management has been developed through sound principles of measuring, predicting performance and managing expenditure on business driven KRA’s

Recommendations

1. Maintain contact with SANRAL on the development of the SAPDM to identify possible advantages for Australia

2. Drive to have road network asset management run on commercial lines or at least on business principles where KRA’s are designed to provide service to the road user and inadequate funding can result in road deterioration or closure.

3. Encourage the use of the performance data to allocate funds reserved for asset preservation and maintenance.

4. Promote the benefit of LTPP linked to APT and the advantage that it brings in pavement modeling and asset & budgetary management.

5. Promote the use of beneficial improvements in materials, pavement structures and management systems including the use and development of:
   a. Non-standard certification of “fit-for-purpose” products
   b. High Modulus Asphalt
   c. Ultra Thin Friction Course proprietary / certified products
3. Overview and Recommendations

3.4 Sustainability

Observations

1. The road is a reusable materials bank
2. Introducing Warm Mix Asphalt and other innovative technologies has been achieved
3. Assessing the Carbon Tax implementations in South Africa

Recommendations

1. Promote the sustainability concept of the “road materials bank” where construction materials in the road network remain in the bank and are sustainably management, improved and reused.
2. Evaluate and report on the legislative and policy implication of the Australian Carbon Tax on road construction, surfaced seals and asphalt production.
3. Identify and share carbon reduction strategies for road surfacing and asphalt manufacturing in Australia.
4. Promote the sustainability credentials and benefits of road building materials including:
   a. Recycled Asphalt Pavements including cold in-place, cold in-plant and Warm Mix Asphalt
   b. Bitumen Stabilised Materials for improving granular material properties
   c. Warm Mix Asphalt as a temperature reducing, asphalt worker friendly and energy efficient asphalt product
   d. Ultra Thin Friction Courses for the preservation of high standard surfacing aggregates
   e. High modulus asphalt Hi MA for reducing pavement thickness and saving on construction materials used in the pavement
   f. Bitumen Rubber binders for their role in reducing the environmental impact of used motor car tyres
   g. Very long life or perpetual pavements (>50 years) where bottom up cracking of asphalt pavements is eliminated and long term maintenance requires only renewal of the wearing course

3.5 General

Observations

1.
3. Overview and Recommendations

Recommendations

1.

2.

3.

4.
4. SURFACE TREATMENTS

Working Group
Leader: John Esnouf
Group: Robert Busuttil, Kym Neaylon, Trevor Distin

The intention is that the views on the concepts and application in practice should be reported on the questions posed and responses when viewed from the three positions of Road Authority / State DOT, road construction industry and where relevant from advisors or researchers.

Tour scope
Surface treatments – Use of spray seals under heavy traffic, Crumb Rubber Binders, Alternate spray seal configurations, Low cost sand seals on low traffic roads, Surface rejuvenation treatments

Feedback from
- SANRAL Western Cape
- SANRAL Head Office Pretoria
- SANRAL KwaZulu Natal
- University of Stellenbosch
- CSIR Built Environment
- eThekwini / Durban Municipality
- Colas South Africa
- Tosas binders division of Sasol
- Gerrie Van Zyl, specialist spray seal consultant

Observations

South Africa, like Australia is large country with a relatively low population density. Thin surfacing treatments combined with granular pavements are used extensively as an economical means of providing an all weather road network. This is reflected in the fact that 90% of South Africa’s sealed network is sprayed sealed.

1. Maintenance programming

While there are similarities with Australian practice local issues and experience have resulted in several different sealing configurations and techniques being adopted, these include triple seals, cape seals and emulsion fog sprays. Of most interest was the use of sprayed seals under heavy traffic conditions.
Differences also exist in the way that the sealed network is allocated and managed between Municipal (Council), Provincial (State) and National (Federal) road authorities. Unlike Australia, national roads are managed directly by the South African National Roads Authority Ltd. (SANRAL). This is an independent statutory authority owned by the South African Government (www.nra.co.za).

SANRAL is funded through two streams,

- Government allocations for non-toll roads
- For toll roads borrowing on money markets or the transfer of roads to the private sector under 30 year build, operate and transfer contractors.

SANRAL avoid doing projects on a worst condition first basis but rather give priority to undertaking preventative maintenance such as resealing and crack sealing. Roads that are in a poor state of repair are maintained in a safe condition (signing, lowering speed limits) until rehabilitation funding can be secured.

Optimisation in the allocation of funding is undertaken using modelling tools such as HDM4 and dTIMS. Figure 4.1 and 4.2 below illustrate SANRAL’s experience with his approach and the reason why it was adopted, simply they are attempting to extract the greatest value from maintenance funding to maintain the road in a good condition.

![Figure 4.1 – Impact on repair costs of delaying maintenance (Kannemeyer 7/9/2011)](image)

Meetings with SANRAL representatives revealed that they believe that this policy has begun to show dividends with an improvement in the condition of their network. This success is reflected by the fact that some roads currently under Provincial control will be handed over to SANRAL within the next few years, increasing SANRAL’s network from 16000 to 32 000 km of road.
In Australia sealing services are generally procured through a contract between the Road Authority and a sealing contractor. In South Africa this is not the case, rather consultants are appointed by the Road Agency to select treatments, design the seal, call contracts and supervise works. The consultant will provide several alternatives but provide a recommended treatment with appropriate justification for the selection. The performance of the seal remains the responsibility of the consultant and sealing contractor for the defects liability period which is 12 months. From a road agency perspective this provides a certain degree of flexibility however there are issues including:

- Increasing failures due to inexperienced consultants appointed through a competitive tender process
- Loss of expertise within the Road Agencies
- Selection of conservative treatments

It was interesting to note that when selecting segments to be treated consideration is also given to achieving the greatest economy of scale possible. It is apparently common to seal long continuous sections up to 80km in length.

Seal selection varied between Provincial and National Roads. An example of this is shown in Figure 4.3 and Figure 4.4 where majority of seals in the Western Cape Province were single seals while predominantly double seals were used on SANRAL roads. This is not unexpected due to National roads carrying the majority of freight movements however an additional factor is the need to limit noise levels on new surfacings to a maximum of 65dBA.

Figure 4.2 – Effect of reactive and preventative maintenance (Kannemeyer 7/9/2011)
4. Surface Treatments

Questions and Responses

AAPA 2011 Study Tour Group Report

**Surface Treatments Questions and Responses AAPA 2011 Study Tour Group Report**

**Figure 4.3 – Surfacing types used in Western Cape 2011 (Van Zyl 5/9/2011)**

**Figure 4.4 – Surfacing types used on SANRAL 2011 (Van Zyl 5/9/2011)**

**Binders**

With regard to binders it is understood that the use of penetration grade bitumens is declining in favour of polymer modified (PMB’s) and crumb rubber binders (CRB). This is due to increasing traffic levels and the need to minimise crack reflection. The type of binders used in South Africa are discussed in Section 5 however in general PMB’s with low levels of modification (2.5% SBS) are commonly used with 20% CRB being preferred where higher levels of modification are required to accommodate higher traffic levels and treat cracking.

African bitumen is graded by penetration while Australian bitumen is graded by Viscosity (refer table 4.1)
Table 4.1 Bitumen grades

<table>
<thead>
<tr>
<th>African grade(pen)</th>
<th>Aus Grade (Vis)</th>
<th>African use</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 - 50</td>
<td>C320</td>
<td></td>
</tr>
<tr>
<td>60 – 70</td>
<td>C170</td>
<td>Asphalt</td>
</tr>
<tr>
<td>80 - 100</td>
<td>C80</td>
<td>Sprayed seal</td>
</tr>
</tbody>
</table>

Australia uses one grade for sprayed sealing and one grade harder for asphalt. This could be why durability is much more important in Australia. This could also explain why cutter is not used (at least, not added on site). MC3000, a 80-100 grade bitumen with 12% cutter, may be ordered in advance.

The South African Polymer modified binder specification is polymer blind (it does not distinguish between polymer types), and a translation of this is offered in Table 4.2

Table 4.2 Polymer Modified Binders

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-E1</td>
<td>Asphalt binder, elastomeric, low polymer (SBS &amp; SBR)</td>
</tr>
<tr>
<td>A-E2</td>
<td>Asphalt binder, elastomeric, medium polymer (mostly SBS)</td>
</tr>
<tr>
<td>A-H1</td>
<td>Asphalt binder, hydrocarbon, 4-5% Gilsonite</td>
</tr>
<tr>
<td>A-H2</td>
<td>Asphalt binder, hydrocarbon, 3-4% Sasobit</td>
</tr>
<tr>
<td>S-E1</td>
<td>Sprayed seal binder, elastomeric, low polymer (SBR, SBS)</td>
</tr>
<tr>
<td>S-E2</td>
<td>Sprayed seal binder, elastomeric, medium polymer (~3%)</td>
</tr>
<tr>
<td>S-R1</td>
<td>Sprayed seal binder, 5% crumb rubber</td>
</tr>
</tbody>
</table>

Emulsion

Emulsions are also popular and appear to be more widely used than in Australia for resealing and rejuvenation. An application not practiced in Australia is the use of a fog spray; this involves a light application of a 50:50 diluted rapid set cationic emulsion binder (0.3 – 0.4 l/m2 residual) applied over a seal to bind the aggregate particles together and prevent early stone loss (Figure 4.5a). In some circumstances it appears this practice is used instead of precoating. Fog sprays are also employed in lightly trafficked areas such as shoulders and outside wheel paths to provide additional binder (Figure 4.5b).
Primes and primerseals

For new works primerseals are not used, rather a prime and seal is preferred. If building a pavement through winter a prime followed by a modified emulsion double seal is employed. When undertaking pavement rehabilitation under traffic it is common practice to build, prime and seal the road in half widths. Access to the road is maintained on the remaining lane through the use of stop/go traffic control that may operate 24 hours per day for as many days as necessary. This is undertaken on sections up to 4km in length.

Reseals

Reseals are not normally undertaken during an ‘embargo’ period from May to August due to poor performance. It is considered that the embargo is partly related to the fact that the use of cutters is discouraged due to the perceived health and safety risks of adding cutter on site and the potential for bleeding in summer. Measures taken to improve aggregate adhesion and hence avoid the use of cutter include:

- Spraying when pavement temperatures are 25°C and rising
- Use of emulsion binders
- Aggregate precoating
- Prevent trafficking of the seal at night. Similar to rehabilitation sealing is performed in lane widths with traffic control used to prevent access to the fresh seal overnight. Rolling and sweeping is undertaken the following day when the pavement has warmed. Traffic is only permitted on the seal when the pavement temperature is above 15°C.

It is recognised that cutter is sometimes necessary, particularly with PMB’s (TG1). In these cases it is preferred that the cutter is added at the refinery or plant. If addition of cutter is required on site the contractor is required to provide a method statement addressing the risks. Maximum cutter levels suggested are 5% for light traffic and 3% for heavily trafficked roads (TG1).

Figure 4.5a – Diagram of diluted emulsion fog spray
Figure 4.5b – Emulsion fog spray outside of wheel paths (Judd 8/9/2011)

Gradings for sealing aggregate are shown in Table 4.3a and 4.3b below. There are three quality grades of aggregate however this only relates to the grading and flakiness values. Polished Stone Values (PSV) and Aggregate Crushing Values (ACV) are identical for all grades; but there is reference in TRH 3 to these values being relaxed for roads with low traffic.

Table 4.3a – Grading for South African sealing aggregates

<table>
<thead>
<tr>
<th>Sieve size (mm)</th>
<th>Grade</th>
<th>26.5 mm nominal size</th>
<th>19.0 mm nominal size</th>
<th>13.2 mm nominal size</th>
<th>9.5 mm nominal size</th>
<th>6.7 mm nominal size</th>
<th>4.75 mm nominal size</th>
<th>2.36 mm nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.50</td>
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<td>6.70</td>
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<td>4.75</td>
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<tr>
<td>3.35</td>
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<td>2.36</td>
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</tbody>
</table>

Grades 1 & 2

<table>
<thead>
<tr>
<th>Grade 3</th>
<th>Grading shall comply with the requirements for grades 1 and 2 with the following exceptions:</th>
<th>* 0 – 50</th>
<th>** 0 – 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fines content: Material passing a 0.425 mm sieve (max)</td>
<td>Grade 1</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Grade 2</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Grade 3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Dust content: Material passing a 0.075 mm sieve (max)</td>
<td>Grade 1</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Grade 2</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Grade 3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 4.3b – Properties for South African sealing aggregates
Aggregate spreaders are commonly used in South Africa, particularly for large sealing jobs as they are considered to provide more control over the aggregate spread rate.

### Slurry

Slurry is used quite extensively in South Africa in the following routine and periodic maintenance applications (Sabita 2011):

- **Initial sealing** - Cape seals (refer below) are commonly used on new works; however slurry applied over a primed base is also used as an initial treatment. As a guide the thickness of slurry should be between the nominal size of the largest aggregate in the mix and 3 times the ALD of the largest aggregate size in the mix. It is recommended that slurry not be used in this application where there is heavy vehicle turning or braking.

- **Resealing** – slurry is applied mainly on low traffic roads as an overlay while quick setting microsurfacing is adopted at higher traffic levels. In this situation mechanised methods of application i.e. continuous mixing machine with a spreader box are used.

- **Maintenance** – slurry and microsurfacing is used in several maintenance applications including rut filling, patching and as a holding treatment until a more permanent repairs can be undertaken. Two interesting maintenance techniques using slurry are texture regulation and repair of edge breaks.

Textures regulation is required when the surface either has a very high texture or where there is a large difference in texture between trafficked on non-trafficked areas. In this application the slurry is normally applied by hand to force it into the voids of the seal. This treatment is not recommended where the surface is bleeding and tacky.

Rather then repair edge breaks individually by hand it has been found to be more economical to sweep and prime the shoulders then fill edges with slurry. A similar application has been used in Australia to seal shoulders.

Similar issues with slurry experienced in Australia also occur in South Africa. These include

- **Embedment** when seals are applied over fresh slurry. A curing period of 12 weeks is recommended. Where ball penetration values are less than 2mm there is considered to be a low risk of excessive embedment (SANRAL 2007).
4. Surface Treatments

- Bleeding when slurry is applied over an existing flush surface or when applied over a cutback seal
- Rapid reflection of active cracks from the underlying surface

**Heavy Duty Spray Seals**

Parts of the SANRAL toll road system are operated by private consortia under a 30 year build, operate and transfer arrangement termed a concession. These roads must be handed back to SANRAL at the expiry of the concession in a specified condition. It is the responsibility of the private operator to maintain the road while achieving the performance properties at the end of the contract. For the operator of the road the emphasis is to do this in the most efficient means possible.

The N3 toll concession contract operates on approximately 400km of road between Gauteng (Johannesburg) and Cedara (Pietermaritzburg). This is a major freight route carrying an AADT of 9500 – 14 000 vehicles per day with 35% heavy vehicles in undulating terrain (Figure 4.5). When resurfacing sections of the existing asphalt pavement, spray seals have been used as a SAM and a highly flexible skid resistance improvement treatment.

*Figure 4.6 – Example of traffic on N3 (source Judd 8/9/2011)*

Under these conditions modified binders are recommended (similar to upcoming Austroads recommendations). Crumb Rubber Binder was selected for these seals due to good initial adhesion, resistance to flow at high temperatures and the ability to apply high binder application.
rates with a lower risk of bleeding. When applying seals under these heavy traffic conditions the following precautions are suggested:

- Avoid the use of cutter
- Stop sealing early to allow trafficking for two hours before the pavement temperature drops below 25°C then close to traffic overnight
- Do not open to traffic if pavement temperature exceeds the softening point of the binder minus 15°C.
- Apply an emulsion cover spray outside of trafficked areas.

The tour group inspected two examples of reseals along this section of road, a 16mm single seal sprayed at an application rate of 2.3 l/m² and a 19/9 double seal applied at 4 l/m². The 16mm seal appeared in very good condition while the 19/9 double seal had some loss of texture but was still quite serviceable. It is believed that the ability to use the high application rates observed are a result of the high engineered ALD of the aggregate, tighter aggregate spread rates allowing a higher proportion of voids in the aggregate and the use of a high percentages of rubber in the binder.

2. Spray Sealing Configurations

While there are some similarities in the types of seal used in South Africa and Australia the following seal configurations unique to South Africa were noted

**Double Seal** – in a South African double seal the first layer of aggregate is laid to achieve a shoulder to shoulder matrix (Figure 4.7a & b). The surface is then rolled with 10 – 12 tonne steel wheeled roller to achieve a tight flat surface. No traffic is permitted on this layer due to the potential for flushing of the seal until the second layer of stone is applied (TRH 3). This suggests that the design allows for an increased volume of voids in the seal due to the smaller aggregate preventing the reorientation of larger aggregate. If the aggregate is not precoated (which does not appear to be standard practice) a dilute emulsion fog spray is applied following the application of the second layer of aggregate to minimise stone loss.

![Figure 4.7a – Shoulder to shoulder matrix (source TRH 3)](image-url)
A variation on the double seal is a one and half seal where the larger aggregate spread rate is increased to allow the second layer of stone to sit between the first layer. This is what would be referred to as double seal in Australia.

**Split seal** – a split seal, triple seal or 19 + double 6.7 seal consists of a 19mm aggregate with two applications of 7mm stone. This type of seal has proven to be successful on high volume roads with traffic up to 9000 v/l/d. The application process involves the following steps:

- Apply a binder tack coat and the 19mm aggregate. The ALD of the 19mm stone is typically 11.0 – 12.0 mm and is spread at a rate of 70 – 80 m²/m³.
- The first application of 7mm acts as a void filler and can be applied with binder (wet method) or without (dry method). Aggregate is spread at a rate of between 220 – 350 m²/m³.
- The surface is rolled with a 5 - 8 ton steel drum roller after which a penetration coat of binder and the second layer of 7mm is applied at a rate of 150 – 170 m²/m³.

Typical binder and aggregate application rates for a range of traffic levels is provided in Table 4.4 below.

**Table 4.4 – Typical Design for 19/6.7/6.7 seal (source TRH3)**

<table>
<thead>
<tr>
<th></th>
<th>Dry method</th>
<th></th>
<th></th>
<th>Wet method</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ELV</td>
<td></td>
<td>1000</td>
<td>2000</td>
<td></td>
<td>1000</td>
<td>2000</td>
</tr>
<tr>
<td>SE-2 tack coat</td>
<td>1.4 hot</td>
<td>1.3 hot</td>
<td>1.1 hot</td>
<td>1.4 hot</td>
<td>1.3 hot</td>
<td>1.1 hot</td>
</tr>
<tr>
<td>19.0 mm</td>
<td>70 m²/m³</td>
<td>70 m²/m³</td>
<td>70 m²/m³</td>
<td>70 m²/m³</td>
<td>70 m²/m³</td>
<td>70 m²/m³</td>
</tr>
<tr>
<td>Cat 65% penetration cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.1 hot</td>
<td>1.1 hot</td>
</tr>
<tr>
<td>6.7 mm choke</td>
<td>300 m³/m³</td>
<td>300 m³/m³</td>
<td>300 m³/m³</td>
<td>250 m³/m³</td>
<td>250 m³/m³</td>
<td>250 m³/m³</td>
</tr>
<tr>
<td>SE-2 penetration coat</td>
<td>1.1 hot</td>
<td>1.1 hot</td>
<td>1.0 hot</td>
<td>1.0 hot</td>
<td>1.0 hot</td>
<td>1.0 hot</td>
</tr>
<tr>
<td>6.7 mm</td>
<td>155 m³/m³</td>
<td>155 m³/m³</td>
<td>155 m³/m³</td>
<td>155 m³/m³</td>
<td>155 m³/m³</td>
<td>155 m³/m³</td>
</tr>
<tr>
<td>Fog Spray (50/50 Cat 65%)</td>
<td>1.1 hot</td>
<td>1.0 hot</td>
<td>1.0 hot</td>
<td>2.45</td>
<td>2.35</td>
<td>2.1</td>
</tr>
<tr>
<td>Total net binder</td>
<td>2.45</td>
<td>2.35</td>
<td>2.1</td>
<td>2.45</td>
<td>2.35</td>
<td>2.1</td>
</tr>
</tbody>
</table>

With this type of seal it is possible to use a large aggregate and hence apply a high binder application rate that may be required for a SAM treatment while achieving a finer texture of a 7mm seal. This would be advantageous where noise is an issue or where high quality aggregate is difficult to source. It has also been suggested that the level of water spray generated is less then other seal types.
Cape Seals – Cape seals consist of 13 or 19mm single seal covered with slurry. The binder application rate used in the single seal is the minimum necessary to hold the aggregate during construction. Generally the slurry is applied by hand. This is for two reasons, firstly due to high unemployment levels labour based methods are preferred and secondly it is possible to force the slurry between the sealing aggregate so that the tops of aggregate are exposed.

![Hand application of slurry for Cape Seal](image)

**Figure 4.8 – Hand application of slurry for Cape Seal**

Cape Seals are mostly used for new works as a low maintenance surfacing. Approximately 10% of new pavements are surfaced with a Cape Seals and are seen as a lower risk option then a spray seal, so much so that 10mm Cape Seals have also been applied as a winter surfacing treatment. Cape Seals have also been successfully applied as a reseal treatment particularly where heavy vehicle turning movements occur (Sabita 2011)

The use of labour based techniques are not considered appropriate for Australia however Cape Seals have been constructed in South Africa using mechanised methods. The issue with using a mixing machine and spreader box is that the sealing aggregate can be completely covered by slurry in areas where there are undulations in the surface. If this is the case the slurry must be designed to carry the traffic.

When applying slurry the sealing aggregate is either fully covered so that the slurry is acting as the wearing surface or it is used to fill the voids between the sealing aggregate as shown in Figure 4.6. Under heavy traffic conditions (> 2000 v/l/day 10% CV) a 19mm Cape Seal is recommended.

![19mm Cape Seal](image)

**Figure 4.9 – 19mm Cape Seal (source Van Zyl 5/9/2011)**
Cape Seals have been used in Australia, though not as a surfacing for a new pavement but rather as a maintenance treatment or as a heavy duty surfacing at rural intersections. Their success has been varied, the main issue seeming to be flushing of the surface. The limited availability of slurry and the logistical issues in co-ordinating a sealing and slurry crew have made the use of Cape Seals in Australia difficult but there could still be potential for their use as an initial treatment under heavy traffic.

3. Low Traffic Sand Seals

Sand seals are similar to a GATT or Otta seal in that a graded aggregate, in this case sand or grit is applied to a thick layer of binder which rises through the sand to form a stable layer (Figure 4.10). The grading typically used for the sand and grit is provided in Table 4.5. 80/100 pen binder is typically used however cutback binders and emulsions are alternatives.

![Sand and Grit Seal](source TRH 3)

**Figure 4.10 – Sand seal**

**Table 4.5 – Grading for sand and grit for surface seals**

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Cumulative % Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand</td>
</tr>
<tr>
<td>6.7</td>
<td>100</td>
</tr>
<tr>
<td>4.75</td>
<td>100</td>
</tr>
<tr>
<td>2.36</td>
<td>0 – 100</td>
</tr>
<tr>
<td>1.18</td>
<td>0 – 50</td>
</tr>
<tr>
<td>0.600</td>
<td>0 – 20</td>
</tr>
<tr>
<td>0.300</td>
<td>0 – 15</td>
</tr>
<tr>
<td>0.150</td>
<td>0 – 2</td>
</tr>
<tr>
<td>0.075</td>
<td></td>
</tr>
</tbody>
</table>

No design method exists for sand seals however the following application rates are suggested as a guide (TRH 3)

- Penetration grade bitumen 80/100 1.1 - 1.3 l/m²
- Cutback bitumen MC 3000 1.2 – 1.4 l/m²
- Bitumen Emulsion Cationic 65 or 70% 1.4 – 1.6 l/m²
As an initial treatment, sand seals are not recommended on roads with traffic exceeding 150 vehicles/lane/day. In this application a life of up to three years is expected. When used as a resal good performance has been experienced on roads carrying 500 vehicles/lane/day (TRH 3).

South African National Parks uses sand seals to surface its 900km of roads within Kruger National Park. Traffic volumes are considered to be low and consist mostly of cars (Louw 16/9/2011). Sand seals were selected for several reasons:

- Sealing aggregate would need to be transported for considerable distances.
- Suitable river sand was available from within the park and so presented a significant cost saving over a quarried aggregate.
- Sand is replenished from up stream sources and was therefore deemed to be a renewable resource.
- The low speed environment in the park (40km/hr) meant that texture was not an issue.

Screening of the sand was required to remove large particles; the resulting grading at two sites is presented in Table 4.6. These gradings are coarser then those recommended in TRH 3 which suggests that 100% of material pass the 4.75mm sieve.

<table>
<thead>
<tr>
<th>Sieve size (mm)</th>
<th>9,5</th>
<th>6,7</th>
<th>4,75</th>
<th>2,36</th>
<th>1,18</th>
<th>0,600</th>
<th>0,300</th>
<th>0,150</th>
<th>0,075</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative % passing</td>
<td>100</td>
<td>97,2</td>
<td>95,9</td>
<td>87,9</td>
<td>59,5</td>
<td>19,1</td>
<td>4</td>
<td>0,5</td>
<td>0,4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>KNP Limpopo</th>
<th>KNP Skukuza</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,5</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>6,7</td>
<td>97,2</td>
<td>99,6</td>
</tr>
<tr>
<td>4,75</td>
<td>95,9</td>
<td>97,3</td>
</tr>
<tr>
<td>2,36</td>
<td>87,9</td>
<td>80,2</td>
</tr>
<tr>
<td>1,18</td>
<td>59,5</td>
<td>43,9</td>
</tr>
<tr>
<td>0,600</td>
<td>19,1</td>
<td>14,2</td>
</tr>
<tr>
<td>0,300</td>
<td>4</td>
<td>2,3</td>
</tr>
<tr>
<td>0,150</td>
<td>0,5</td>
<td>0,6</td>
</tr>
<tr>
<td>0,075</td>
<td>0,4</td>
<td>0,4</td>
</tr>
</tbody>
</table>

The methods used to construct a sand seal are similar to that of a traditional spray seal apart from the sand being swept back over the wheel paths over a period of several weeks to prevent pick up. When used as an initial treatment the sand seals in the Park were constructed in two stages.
### Primary Seal

- **Prime MC 30 (AMC 0)**
  - 0.80 l/m²
- **80/100 pen bitumen**
  - 1.35 l/m² hot
- **River sand**
  - 70 – 90 m²/m³

Roll with 22 ton pneumatic tyred roller; remove remaining sand after one month

### Secondary Seal applied six months after the Primary Seal

- **80/100 pen bitumen**
  - 1.30 l/m² hot
- **River sand**
  - 70 – 90 m²/m³

Roll with 22 ton pneumatic tyred roller; remove remaining sand after one month

Figure 4.11a and 4.11b show the spreading and rolling operations while Figure 4.12 shows the seal after several days of trafficking. The surface of the sand seals observed were similar in texture to that of dense graded asphalt (Figure 4.13).

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**Figure 4.11a - Sand spreading (Louw 16/9/2011)**

**Figure 4.11 b – Rolling (Louw 16/9/2011)**
Figure 4.12 – Seal after several days of traffic (Louw 16/9/2011)

Figure 4.13 – Surface of completed sand seal
When used as an initial treatment sand seals are normally resealed after 3 years. With regular maintenance including crack sealing they have lasted between 15 – 20 years.

The issue of hauling material long distances is one that is also faced by Australia. By utilising locally available materials in Sand seals or Graded Aggregate seals it should be possible to provide an economical surfacing for low volume roads such as in isolated townships where a surfacing with low texture will be desirable.

4. Surface rejuvenation

Rejuvenation of aged seals is a common practice in South Africa and usually involves the application of diluted anionic emulsion or proprietary inverted emulsion. No formal design method exists however it is suggested that 0.8 – 1.0 l/m² of emulsion diluted with water at a ratio of 1:1 is typical. Trial sections (Figure 4.14) at varying residual binder application rates are usually undertaken on the surface to be treated to determine the most appropriate rate.

![Figure 4.14 – Determining application rate for rejuvenation treatment (source Van Zyl 5/9/2011)](image-url)

When determining if rejuvenation is appropriate consideration is given to both providing sufficient texture after the treatment is applied but also accommodating traffic while the treated area is closed for several hours. From observations during the tour closing relatively long sections of lane for extended periods is common practice. The expected life of rejuvenation is 3-4 years. It was indicated that it can also fill small cracks however the pavement should be in relatively good condition with oxidation of the binder being the main defect.
Summary and recommendations

South Africa faces many of the same challenges to Australia in the maintenance of a large road network with minimal funding and increasing traffic. Spray seals and thin surfacings are used extensively to meet these challenges. While some surfacings practices and methodologies are similar to those used in Australia there are several approaches that could be considered by Australian Road Authorities, these include

- Schedule periodic maintenance (spray sealing, slurry) as a preventative maintenance treatment rather then applied on a worst first basis. Provide input on South African asset management practice into Austroads project AT1536 Good practice in reseal programming

- Increased use of spray seals on heavily trafficked roads. Crumb Rubber binders have provided an increase in service life over other modified binders. Trialing of South African double seals should be undertaken to assess their effectiveness with locally produced crumb rubber binder

- Rejuvenation is a widely accepted practice that can extend the life of a seal by 3 – 4 years. In Australia this practice has declined in recent years, the reasons for this should be investigated and means to overcome any issues considered.

- Trial other South African spray seal configurations and aggregate spread rates to assess their suitability.
Surface Treatments - Questions & Responses

SPRAYED SEALS

Q 1. What percentage of the South Africa network is sprayed seals.

Overall approximately 90% of roads with 95% in rural areas, 60% in smaller towns and urban areas are spray sealed.

Q 2. What are the most common seal types, and aggregate sizes

Similar seal types to those in Australia are used with single and double seals being the most common. The type of seal used varies between agencies. On National roads double seals are used more which is a reflection of the type and volume of traffic on these roads. On Provincial roads single seals for resealing and Cape seals for new works dominate.

Q 3. How commonly used are Cape seals, has there application been mechanised, what traffic loading can be accommodated?

Cape seals make up 10% of the surfacings program. At present the incentive is to use labour based methods for the application of slurry due to Government policy and the ability to squeeze slurry into the voids of the underlying seal. Application of slurry through mechanised means has been undertaken but is not preferred under heavy traffic due to the potential for bleeding as traffic runs on the slurry rather then the large aggregate.

High traffic Cape Seal

- Close matrix
- Drier slurry
- Hand applied

Source: Van Zyl 2011
Q 4. **What standard operations are used in sprayed sealing, are bitumen sprayers uniformly calibrated across the country, are bitumen sprayers certified to use in other jurisdictions?**

Fixed pit calibration facilities are located in Durban and Pretoria however the centre in Pretoria is currently not operational. Annual certification is accepted across South Africa by all Road Authorities. A bucket test (figure below) where the project binder is sprayed into containers and weighed is undertaken at the start of a project to confirm that the sprayer is achieving a uniform transverse distribution.


![Sprayer Calibration](image-url)

Source - van Zyl 2011

Q 5. **Are bitumen rubber & polymer modified binder sprayers different to normal bitumen sprayers – are they calibrated & certified differently?**

Sprayers are not calibrated differently for different products. Sprayers dedicated to applying Crumb Rubber Binders have the following unique features

- Augers in the bottom of the tank to keep the rubber in suspension.
- Double heating flues
- Heavy Duty Pumps
- Larger spray nozzles (35 – 40 l/min)

Q 6. **How are road surface types selected, is there a local or national norm, what factors are considered when selecting the given surface? Are there particular treatments used for particular reasons?**

The type of surfacing is selected based on similar factors as in Australia, traffic volume, road geometry, pavement condition. Other factors include the need to use labour based construction
and the local maintenance capability. For example Cape seals may be specified where there is a low level of maintenance expected.

Guidance on the use of particular treatment is provided in TRH3 Design and Construction of Surfacing Seals.

**Q 7. Is the type of binder to be used included in the selection process or is that determined by the seal design process?**

The type of binder is a function of the traffic, road geometry and pavement condition and so forms part of the selection process. On national roads this process is undertaken by a consultant appointed by SANRAL who recommends a treatment and provides a basis for the selection. TG1 provides guidelines on the selection of the binder type which should be used. SANRAL only use modified binders on all their seals.

**Q 8. Are polymer modified emulsions used in sprayed sealing? If yes what are the key motivators and what are the operational and cost implications?**

Modified emulsions are used extensively due to ability to be applied in a wider range of climatic conditions and as a SAM treatment. There is a cost penalty which ranges from 10 to 50% extra in comparison to a hot unmodified binder.

**Q 9. Does the public sector participate in sprayed sealing (percentage private to public)?**

This varies between the Provinces, but some still undertake their own sealing on low volume roads. The majority of work is undertaken via contract.

**Q 10. Are binders bought in bulk by the client? If yes how is binder allocated to contracts?**

Generally no however there are instances when a client will purchase directly from a refinery on an ad-hoc basis.

**Q 11. Are newer sprayers with different international technologies being used?**

Sprayers are mostly sourced from the United States (Bearcat, Etnyre, Rosco) and France (Acmar). Features of some of these sprayers include oil jacketed spray bars, extendable spray bars and computer controlled spray nozzles.

**Q 12. Has the comparative performance of the various polymer modified binders and rubber bitumen used in seals been reviewed?**

Studies have been undertaken in the past but nothing recently. Data from PMS systems as shown in the figure below give an indication. This together with field observations suggest that that crumb rubber binders are providing superior performance and longevity.
Q 13. What has been the experience with performance of SBS seals with the onset of winter?

The use of SBS binder leading into winter is considered a high risk activity especially considering the reluctance to use cutters due to the risk of bleeding in the following summer. In these circumstances modified emulsions are used particularly for new works.

Some concern was expressed over stone loss occurring on SBS seals in winter months. Banded softening point limits have been introduced in the TG1 specifications for PMB’s to avoid over modification.

Q 14. Have performance or functional specifications been used in the purchase of surface seals?

These are yet to be introduced.

Q 15. Are there best practice procedures for:
   a. surface pre-treatments including rut filling,
   b. surface rejuvenation and crack sealing;
   c. cutting back of binders,
   d. the use of bitumen emulsions;
   e. use of self propelled chip spreaders versus spreader boxes,
   f. calibration of sprayers,
   g. on site blending of bitumen rubber,
   h. pre-coating of aggregates, and
   i. priming of base courses.

Sabita (South African Bitumen Association), SANRAL and the Asphalt Academy have published manuals, guidelines and codes of practice that cover these topics. Several are in the process of being updated. Publications of particular relevance include

- Manual 31: Guidelines for calibrating a binder distributor and ensuring satisfactory performance
- TG1: The use of modified binders in road construction
- Manual 26: Interim guidelines for primes and stone precoating fluids
Q 16. What allowances are made in the variations of material qualities to achieve optimal use of scarce natural aggregates? Is this included integrated into the seal design and the performance evaluation?

Three grades of aggregate quality are available however this related mainly to grading and flakiness. There are requirements for aggregate crushing value and PSV which are constant. Specification requirements have successfully been relaxed on low traffic roads.

Q 17. What impacts have industrial occupational health and safety requirements had on sprayed sealing operations and materials selection?

With regards to material selection tar based products were used extensively in South Africa and provided excellent performance, these materials are now banned due to the health and environmental risks associated with their use. In addition where labour based methods are employed emulsions are being adopted to minimise exposure to hot binders.

Q 18. What allowance is made in the design spray rate to differentiate between the performance properties of the different binders

In the South African spray seal design method there is an upper binder limit to achieve a desired texture level and a minimum binder rate to prevent stone loss. What rate is selected depends on the required performance. If the treatment is intended as a SAM then the upper limit could be selected while the lower limit may be used if there is a risk of an increase in traffic volumes.

Through experience and a process of back calculation adjustment factors have been developed for PMB and Crumb Rubber binders. These are shown in the table below for a PMB with low modification (S-E1), PMB with high modification (S-E2) and a Crumb Rubber binder (S-R1). It is recommended that a minimum practical application rate for Crumb Rubber binder is 1.8 l/m2 for a summer grade and 1.6 l/m2 for a winter grade.

<table>
<thead>
<tr>
<th>Traffic (ELV)</th>
<th>Single seal</th>
<th>Double Seal</th>
<th>Split application double seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5000</td>
<td>1.3</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>5000 - 20000</td>
<td>1.2</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>&gt; 20000</td>
<td>1.1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
### S-E2 ADJUSTMENT (Conventional to modified binder)

<table>
<thead>
<tr>
<th>Traffic (ELV)</th>
<th>Single seal</th>
<th>Double Seal</th>
<th>Split application double seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5000</td>
<td>1.4</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>5000 - 20000</td>
<td>1.3</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>&gt; 20000</td>
<td>1.2</td>
<td>1.0</td>
<td>1.1</td>
</tr>
</tbody>
</table>

### S-R1 ADJUSTMENT (Conventional to modified binder)

<table>
<thead>
<tr>
<th>Traffic (ELV)</th>
<th>Single seal</th>
<th>Double Seal</th>
<th>Split application double seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5000</td>
<td>2.0</td>
<td>1.8</td>
<td>- ?</td>
</tr>
<tr>
<td>5000 - 20000</td>
<td>1.9</td>
<td>1.7</td>
<td>- ?</td>
</tr>
<tr>
<td>&gt; 20000</td>
<td>1.8</td>
<td>1.6</td>
<td>- ?</td>
</tr>
</tbody>
</table>

Source – Louw 2011

**Q 19. What tests and acceptance criteria are used for granular base course prior to sealing**

Density and dry back to 50% of optimum moisture content are required. While ball embedment testing is undertaken as it is an essential part of the seal design method there are no specified limits for surface hardness. However there appears to be an implied limit of 4.0mm as this is highest value that can be accommodated in the seal design charts in TRH3.

**Q 20. What is the maximum traffic volumes and other limiting factors used for spray seals selection**

From discussion it appeared that there was no specific maximum traffic volume however when we look at the seal design method guidance on this topic is given. The table below (TRH 3) recommends surfacing types based on traffic for initial seals. As the volume increase small seals and single seal are not recommended, with only asphalt, Cape seals and double seals suggested at the high traffic end to allow for embedment.
There is not a similar table for reseals however the seal design charts do have a maximum elv/lane/day depending on the aggregate ALD and seal type (single or double seal). An example chart for an ALD of 10mm is shown below. Based on this it is possible to derive limiting values for certain seal sizes as shown in the table below.

<table>
<thead>
<tr>
<th>Approximate Seal Size</th>
<th>ALD</th>
<th>Maximum Traffic (elv/lane/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Single Seal</td>
</tr>
<tr>
<td>7mm</td>
<td>4</td>
<td>10 000</td>
</tr>
<tr>
<td>7mm</td>
<td>5</td>
<td>20 000</td>
</tr>
<tr>
<td>10mm</td>
<td>6</td>
<td>20 000</td>
</tr>
<tr>
<td>10mm</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>14mm</td>
<td>8</td>
<td>40 000</td>
</tr>
<tr>
<td>14mm</td>
<td>9</td>
<td>40 000</td>
</tr>
<tr>
<td>14mm</td>
<td>10</td>
<td>40 000</td>
</tr>
<tr>
<td>16mm</td>
<td>11</td>
<td>60 000</td>
</tr>
<tr>
<td>16mm</td>
<td>12</td>
<td>60 000</td>
</tr>
<tr>
<td>↓ 22</td>
<td></td>
<td>60 000</td>
</tr>
</tbody>
</table>
The traffic volumes in equivalent light vehicles per lane per day is calculated by adding the volume of light vehicles to 40 times the volume of heavy vehicles. So 40 000 elv/lane/day equates to approximately 8500 v/l/d with 10% commercial vehicles.

**Q 21. How do they address seal failures ie bleeding, flushing, stripping, ravelling etc?**

Bleeding - a solvent (power paraffin) is applied to the flushed areas and given time to soften the binder, precoated stone in then rolled in. A variation on this method is to precoat 7mm stone with the solvent at a rate of 9 – 14 l/m³ and roll into the flushed areas. For large areas a light application of diluted emulsion (0.2 – 0.3 l/m² residual) is applied as a tack coat over which aggregate is spread and rolled.

Dry matting is also practiced where a dry application of stone is placed on the flushed areas and a reseal placed on top.

Stripping – in the early stages a fog spray of diluted cationic rapid set emulsion is used to arrest aggregate loss. Where stripping has progressed matting (back chipping) is undertaken.

Raveling – a rejuvenation spray, a cutback binder with grit or a slurry surfacing have been used.

**Q 22. How is funding for sealing and maintenance procured? How are sites for sealing selected? What process is used to rank these sites?**

**Source – TRH 3**
Funding and site selection are linked to the pavement management system. Different approaches are taken depending on the authority. Modeling tools such as HDM4 and dTIMs are used to present scenarios when bidding for funds. These tools are also used to give sites that will be in need of periodic maintenance. This is generally supplemented by visual inspections to confirm or if needed change the PMS models selection.

**Q 23. What percentage of roads is resealed annually? What is the life expectancy of seals in South Africa?**

The life expectancy of seals is generally between 8 – 15 years however on initial seals this can be a low as 3 years. The table below gives expected seal lives for a range of treatments and traffic levels. The percentage of roads resealed is below 7% with a back log of work building. One example was given of a road authority not having undertaken any sealing for 6 years.

<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>Traffic (2axle)</th>
<th>New Construction seals</th>
<th>Repair on existing structure seals</th>
<th>Repair on structure with fatigue cracking seals</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.7 mm and sand</td>
<td>&lt;=20000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>&gt;20000</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5.5 mm and sand</td>
<td>&lt;=20000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>&gt;20000</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>11.1 mm and sand</td>
<td>&lt;=20000</td>
<td>12</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>&gt;20000</td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>13.8 mm and sand</td>
<td>&lt;=20000</td>
<td>14</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>&gt;20000</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>18 mm</td>
<td>&lt;=20000</td>
<td>16</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>&gt;20000</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>13 mm</td>
<td>&lt;=20000</td>
<td>12</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>&gt;20000</td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>20 mm</td>
<td>&lt;=20000</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>&gt;20000</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>24 mm</td>
<td>&lt;=20000</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>&gt;20000</td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

**Note:**

** Equivalent Light Vehicles (eLV) - 1 heavy vehicle = 40 light vehicles
4. Surface Treatments

Questions and Responses

AAPA 2011 Study Tour Group Report

Source – TRH 3

Q 24. To what extent are geotextile seals used? Are there any guidelines for the use of geotextile seals in areas of high stress?

Geotextiles are limited to isolated patching. Full width sealing is rarely undertaken. There are limited guidelines however these do not cover the use of geotextiles in high stress areas.

What properties are specified for sealing aggregates? Is a minimum average least dimension required?

Properties for sealing aggregates are provided in the two tables below.

<table>
<thead>
<tr>
<th>Sieve size (mm)</th>
<th>Grade</th>
<th>26.3 mm nominal size</th>
<th>13.2 mm nominal size</th>
<th>9.5 mm nominal size</th>
<th>6.7 mm nominal size</th>
<th>4.75 mm nominal size</th>
<th>2.38 mm nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td>37,50</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>26.50</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>19.00</td>
<td>0 - 30</td>
<td>0 - 100</td>
<td>0 - 100</td>
<td>0 - 30*</td>
<td>0 - 100</td>
<td>0 - 100</td>
<td>0 - 100</td>
</tr>
<tr>
<td>13.20</td>
<td>0 - 5</td>
<td>0 - 100</td>
<td>0 - 100</td>
<td>0 - 100</td>
<td>0 - 100</td>
<td>0 - 100</td>
<td>0 - 100</td>
</tr>
<tr>
<td>9.50</td>
<td>-</td>
<td>0 - 5</td>
<td>0 - 10</td>
<td>0 - 30*</td>
<td>0 - 100</td>
<td>0 - 100</td>
<td>0 - 100</td>
</tr>
<tr>
<td>6.70</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0 - 10</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4.75</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3.35</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2.36</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Grading shall comply with the requirements for grades 1 and 2 with the following exceptions: * 0 – 50 **0 – 10

Source – TRH 3

Q 25. Bitumen rubber seals using high binder application rates have been reported (Jooste K & van Zyl GD 2010). How are these seals performing? Under what conditions are they used?

These were originally intended as a holding treatment but have and are still performing well, in particular the 19/9.5mm seals.
SLURRY SEALS

Q1. What is the primary use of slurry seals? Urban networks? Rural network?

In urban environments slurry is used mainly for overlays while in rural applications include texture regulation, rut filling, routine patching and Cape seals

Q2. Are slurry / micro-surfacings used as rut filling and overlays? What life expectancy is achieved? What mix design methods are used? Any lessons learnt or best practice guides? Are there performance records?

Slurry is used for rut filling however the mix design can be different depending on the rut depth with a coarser grading being needed for deeper ruts (30mm). The mix design method and guidelines are set out in Sabita Manual 28: Best practice for the design and construction of slurry seals. An interesting on site quality control tool is the consistency test. Similar to a slump test for concrete slurry is applied on a plate with concentric rings. The degree that the slurry spreads is an indicator of the workability of the mix.

Source – Sabita 2011

Q3. Is the equipment used of a similar type / standardised?

Equipment is not standardised as such. For labour based techniques concrete mixers are commonly used while for overlays and rut filling continuous mixing machines similar to those used in Australia are employed.

Q4. Are slurry / micro-surfacings sold under brand names? Are they included in a HAPAS type certification process?

Slurry is not considered a proprietary product and as such is not included in a certification program. Microsurfacing which makes use of special quick breaking PMB emulsions is supplied as a proprietary product by Colas for rut filling and overlay material
Q5. *Are they using PMB emulsions in their slurry seals if so what kind?*

Specifications for modified emulsions AC-E1 and AC-E2 used in slurry are detailed in the table below. Further details on PMB emulsions can be found in section 5.

![Table](image)

**REJUVENATION**

**Q 1. Is surface enrichment a common practice?**

Rejuvenation is widely used throughout South Africa as an inexpensive means of extending a seals life. 95% of Namibia surfaced road network is rejuvenated before it is resealed.

**Q 2. What is the primary motivation for using surface rejuvenation?**

Rejuvenation is considered where the seal binder is oxidized and brittle and so is susceptible to stripping if not treated. There must be enough voids in the seal to accommodate the additional binder.

Rejuvenation also helps close up hairline cracks under traffic and improve surface impermeability.

**Q 3. Is it included in seal design and application?**

There is no formal design process, as a guide application rates are in the order of 0.8 – 1.0 l/m² of diluted (50/50) emulsion. Small trial sections are applied to determine the most appropriate rate and dilution rate however a minimum 25% binder content is recommended.

**Q 4. What selection/performance criteria are used in choosing a surface enrichment product?**

This is generally based on experience. Stable grade (slow set) emulsions are generally used as they tend to break more slowly and flow into the voids in the seal.

**Q 5. What application rates are used? What are the costs/area of the products used?**

Between 0.8 and 1.0 l/m² of a 50:50 diluted emulsion is used i.e. 0.25 and 0.3 l/m² residual binder. Cost of rejuvenation varies between R5.00/m² and R7.00/m².
Q 6. **What binder types are used for surface enrichment?**

Emulsions using penetration grade bitumens are most common. The intent is for the binder to penetrate into the voids of the seal so it is essential to achieve a low viscosity which is the reason why diluted slow set emulsions are used. CRS 60 dilute emulsions are not used because they contain flux and remain tacky in hot weather. The binder will also tend to be deposited on the surface of the stone and not flow into the voids.

Q 7. **Are special commercial products / petroleum product formulations used for rejuvenation?**

Cutback binders are not used for rejuvenation. Commercial products tend to be inverted emulsions containing aromatic oils.

Q 8. **What are the life cycle cost benefits of surface rejuvenation?**

Rejuvenation increases the seal life by 3 – 4 years with some seals receiving up to 3 rejuvenation sprays before resealing.

Q 9. **What rejuvenation treatments are used on asphalt surfaced pavements where the environment rather than loading is the major influence on deterioration? (eg low volume residential streets in cities)**

Rejuvenation treatments are not normally used on asphalt and it is also not recommended on residential streets. A proprietary product called SP 2000 is used for rejuvenation asphalt surfaces
Reference Material

1. List the presentations or other material gathered during the tour.


3. Judd presentation given 8\textsuperscript{th} September 2011

4. Louw, Van Zyl presentation given 5\textsuperscript{th} September 2011


7. Van der Walt, presentation given 5th September 2011
5. BINDERS

Working Group
Leader: Trevor Distin
Group: Robert Busuttil, Peter Evans, Kym Neaylon

Tour scope
The key focus under binders was to learn more about the use of crumb rubber bitumen (CRB) in spray seals and asphalt, its availability and specification requirements including quality control measures to ensure compliance. Other areas of interest included the use of polymer modified emulsions in spray seals and development in performance specifications for binders.

Feedback from
- Kobus Louw – Technical Development Manager Colas Southern Africa
- Johan Muller – Technical Manager, Bitumen and Road Binders, Sasol Oil
- Johan O’Connell – Research Chemist, CSIR
- Gerry Van Zyl – Spray Sealing specialist and Consulting Engineer
Observations

South Africa consumed 450,000 tonnes of bitumen in 2010. Traditionally South Africa has been a net exporter of bitumen but is experiencing shortfalls in bitumen supply during peak demand, limited storage facilities at the refineries and due to changes in clean fuels specifications. Refined bitumen grades are classified according to their penetration range but also specification limits for viscosities @ 60 & 135°C and softening point. They are considering moving away from empirical tests towards more performance based properties for all refined bitumen specifications.

All modified bitumens, including emulsions and crumb rubber, for use in spray seals, asphalt, microsurfacings and crack sealants are specified in a document called Technical Guideline 1. The binder requirements are polymer blind and based on a similar nomenclature system as Austroads T190. They have recently introduced upper limits on softening point requirements for all PMBs.

*Modified binder classification system, Source: TG1*

<table>
<thead>
<tr>
<th>Modified Binder Class</th>
<th>Application – Surface Seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>S – E1</td>
<td>Surface seal – hot applied elastomer modified</td>
</tr>
<tr>
<td>S – E2</td>
<td>Surface seal – hot applied elastomer modified</td>
</tr>
<tr>
<td>S – R1</td>
<td>Surface seal – hot applied bitumen rubber</td>
</tr>
<tr>
<td>SC – E1</td>
<td>Surface seal – emulsion elastomer modified</td>
</tr>
<tr>
<td>SC – E2</td>
<td>Surface seal – emulsion elastomer modified</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Modified Binder Class</th>
<th>Application – Premixed Asphalt</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – E1</td>
<td>Hot mix asphalt – elastomer modified</td>
</tr>
<tr>
<td>A – E2</td>
<td>Hot mix asphalt – elastomer modified</td>
</tr>
<tr>
<td>A – P1</td>
<td>Hot mix asphalt – plasticiser modified</td>
</tr>
<tr>
<td>A – H1</td>
<td>Hot mix asphalt – hydrocarbon modified</td>
</tr>
<tr>
<td>A – H2</td>
<td>Hot mix asphalt – hydrocarbon modified</td>
</tr>
<tr>
<td>A – R1</td>
<td>Hot mix asphalt – bitumen rubber</td>
</tr>
<tr>
<td>AC – E1</td>
<td>Microsurfacing – emulsion elastomer modified</td>
</tr>
<tr>
<td>AC – E2</td>
<td>Microsurfacing – emulsion elastomer modified</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Modified Binder Class</th>
<th>Application – Crack Sealant</th>
</tr>
</thead>
<tbody>
<tr>
<td>C – E1</td>
<td>Crack sealant – hot applied elastomer modified</td>
</tr>
<tr>
<td>CC – E1</td>
<td>Crack sealant – emulsion elastomer modified</td>
</tr>
<tr>
<td>C – R1</td>
<td>Crack sealant – hot applied bitumen rubber</td>
</tr>
</tbody>
</table>
Typical types and percentages of polymers used in modified binders

<table>
<thead>
<tr>
<th>Grade</th>
<th>Modifier type &amp; percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>S - E1 &amp; A – E1</td>
<td>2.5 % SBS or 5% SBR latex</td>
</tr>
<tr>
<td>S – E2 &amp; A- E2</td>
<td>&gt; 4 % SBS</td>
</tr>
<tr>
<td>S – R1 &amp; A – R1</td>
<td>20 – 24 % crumb rubber</td>
</tr>
<tr>
<td>A – P1</td>
<td>&gt; 5% EVA</td>
</tr>
<tr>
<td>A – H1</td>
<td>&gt; 5% Gilsonite</td>
</tr>
<tr>
<td>A – H2</td>
<td>&gt; 4% Sasobit</td>
</tr>
</tbody>
</table>

More extensive use is made of bitumen emulsions in road construction and maintenance techniques such as sprayed seals, enrichment sprays, primes, stabilization, crack sealants, bond coats, microsurfacings and slurries. Polymer modified emulsions are used in winter to allow construction of new seals at lower ambient temperatures.

A softer grade of bitumen is used for sprayed seals compared with Australian practice. Very little use is made of petroleum solvents in cutting back binders for spray sealing. Hot binders are only sprayed when the road surface temperatures exceeds 25°C and is rising. Dilute emulsions are sprayed over new seals to prevent early live stone loss under traffic.

1. Bitumen supply and specifications

South Africa has 4 refineries located at Durban (Shell/BP & Engen formerly Mobil), Cape Town (Caltex) and Sasolburg (Sasol/Total) which produce the following grades of bitumen:

Refined bitumen grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>Use</th>
<th>Australian equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>80/100</td>
<td>Spray seal</td>
<td>C80¹</td>
</tr>
<tr>
<td>60/70</td>
<td>Asphalt wearing course</td>
<td>C170</td>
</tr>
<tr>
<td>40/50</td>
<td>Asphalt base course</td>
<td>C320</td>
</tr>
<tr>
<td>MC 30</td>
<td>Cut back prime</td>
<td>AMC 0</td>
</tr>
<tr>
<td>MC 3000</td>
<td>Cutback spray seal</td>
<td>AMC4</td>
</tr>
</tbody>
</table>

Note: South Africa does not cutback their spray grade bitumen (which is equivalent to a C80) with kerosene on-site whereas in Australia we use a harder bitumen (C170) and cut it back.

The bitumens are refined to meet rheological properties across the expected performance temperature spectrum in road applications. To this end specification ranges are set based on meeting before and after RTFOT limits for:
- Penetration @ 25°C
- Viscosity @ 60°C
- Viscosity @ 135°C
- Softening point

[SANS 307 framework]

Source: Sabita Manual 2

Figure: Graphical illustration of empirical binder properties over their temperature spectrum.

Work is being done under the auspices of the CSIR to develop a ‘simple’ performance grade specification which will render a seamless test regime across all types and grades of binders using the following performance criteria and tests to measure:

- Stiffness (G*) and elastic behaviour (phase angle) with the dynamic shear rheometer at maximum in-service temperature
- Short term aging temperature susceptibility using dynamic viscosity after RTFOT
- Long term aging performance using PAV and DSR
## Draft performance specification for binders

<table>
<thead>
<tr>
<th>Binder class</th>
<th>58S</th>
<th>64S</th>
<th>64H</th>
<th>64V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre RTFOT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average 7 day max pavement design temperature (°C)</td>
<td>&lt;58</td>
<td>&lt;64</td>
<td>&lt;64</td>
<td>&lt;64</td>
</tr>
<tr>
<td>DSR IG*I/sinδ_ min 1.0</td>
<td>@58 °C</td>
<td>@64 °C</td>
<td>@64 °C</td>
<td>@64 °C</td>
</tr>
<tr>
<td>Viscosity Pa.s (DSR) @135 °C</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
</tr>
<tr>
<td>Flash point (°C)</td>
<td>&lt;230</td>
<td>&lt;230</td>
<td>&lt;230</td>
<td>&lt;230</td>
</tr>
<tr>
<td>% recovery at δ=3.2 kPa</td>
<td>N/A</td>
<td>N/A</td>
<td>&gt;15</td>
<td>&gt;30</td>
</tr>
<tr>
<td>Storage stability @160°C Maximum difference between top and bottom</td>
<td>N/A</td>
<td>N/A</td>
<td>0.3 kPa @ 64 °C</td>
<td>0.3 kPa @ 64 °C</td>
</tr>
<tr>
<td><strong>Post RTFOT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass change (m/m%, max)</td>
<td></td>
<td></td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Jnr (at δ=3.2 kPa)</td>
<td>≤4.0 kPa-1 @ 58 °C</td>
<td>≤4.0 kPa-1 @ 64 °C</td>
<td>≤2.0 kPa-1 @ 64 °C</td>
<td>≤1.0 kPa-1 @ 64 °C</td>
</tr>
<tr>
<td>A, VTS parameters</td>
<td>Report only</td>
<td>Report only</td>
<td>Report only</td>
<td>Report only</td>
</tr>
<tr>
<td>Rolling stones test (%cover)</td>
<td>40</td>
<td>40</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td><strong>PAV binder @ 100 °C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSR IG*Isinδ (Max)</td>
<td>5,000 kPa @ 22 °C</td>
<td>5,000 kPa @ 22 °C</td>
<td>6,000 kPa @ 22 °C</td>
<td>6,000 kPa @ 22 °C</td>
</tr>
</tbody>
</table>

Source: Johan O’Connell

Use is being made of the Witczak equation and Hirsh models to predict dynamic modulus of asphalt which supports the Mechanistic Empirical design model being developed for asphalt.
2. Use of Crumb Rubber Bitumen

Crumb Rubber Bitumen (CRB) is considered the preferred modified binder for use in spray seals and some asphalt applications. CRB are used mainly for resealing over existing cracked surfaces as a SAM. CRB is also used in open and semi open graded asphalt and dense graded asphalt wearing courses.

The main benefit of using CRB are that a higher application of binder can be placed due to the increased viscosity of the binder without the risk of bleeding. The higher application rates and film thicknesses result in more durable surfacings. The carbon black component of the rubber also serves as an antioxidant thus providing UV protection to the binder.

Experience in South Africa suggests that CRB seals have improved service lives compared to polymer modified binder seals. This is demonstrated in Figure 1 which is derived from the observations made using the PMS rating system for assessing spray seals in the Western Cape. It shows the typical life of a binder before it is oxidized to a certain hardness as being:

- PMBE = 6 years
- SBS or SBR modified = 9 years
- CRB = 13 years.
### Hardening/ Oxidation (WCPA)

**13,2 mm Modified Binders**

![Graph showing rate of hardening/oxidation of binder types in single seals.]

**Rate of hardening/oxidization of binder types in single seals**

*Source: Gerry van Zyl*

#### Blend components

80/100 penetration grade base bitumen is used with typically 2% aromatic oil. Between 20 – 24% size 30 mesh rubber crumbs are used. Preblending of CRB is mandated because the binder properties can be checked prior to use.

#### Specifications and quality control

The binder must be formulated and blended to meet end binder properties shown in Table 3. A hand held Haake or Rion rotational viscometer is used as an on-site acceptance control measure before spraying the CRB.

**Crumb rubber binder properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>SR – 1</th>
<th>AR - 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity @ 190°C (dPa.s)</td>
<td>20 – 40</td>
<td>20 - 50</td>
</tr>
<tr>
<td>Softening point (°C)</td>
<td>55 – 62</td>
<td>55 – 65</td>
</tr>
<tr>
<td>Flow @ 60°C (mm)</td>
<td>15 - 70</td>
<td>10 – 50</td>
</tr>
<tr>
<td>Resilience @ 25°C (%)</td>
<td>13 - 35</td>
<td>13 - 40</td>
</tr>
<tr>
<td>Compression recovery (%)</td>
<td>5 min &gt; 70</td>
<td>5 min &gt; 80</td>
</tr>
<tr>
<td></td>
<td>1 hour &gt; 70</td>
<td>1 hour &gt; 70</td>
</tr>
<tr>
<td></td>
<td>4 days &gt; 25</td>
<td></td>
</tr>
</tbody>
</table>

*Source: TG1*
Prior to starting a project the supplier will provide a set of graphs showing the change in the CRB properties at the different temperatures over time. This allows for easy measurements to be made on-site using a hand held viscometer to check at what stage the CRB has digested or degraded before use. This is also a good indicator of shelf life of the CRB using different raw materials and blending procedures.

Special care needs to be taken when testing asphalt which has been manufactured using CRB. Not all the rubber crumbs are digested and can effect the binder content determinations if done by solvent extraction and the % passing the 0.075mm sieve size will be higher. The asphalt volumetric properties will also vary over time due to the ongoing change in the binder properties as can be seen below.

![Graph showing typical changes in bulk relative density of the asphalt mix over time](image)

*Typical changes in bulk relative density of the asphalt mix over time*

*Source: Sabita Manual 19*
Example of a hand held field rotational viscometer

Reheating of CRB samples will also result in a change in the binder properties and therefore it is preferred that the samples are prepared for testing before application.
Manufacture of CRB

Only the preblend or ‘wet’ method is utilised in RSA for blending CRB for use in both spray sealing and asphalt. Blending of the CRB is also done closest to the point of use. High speed mixing technology is used to blend the rubber crumb with bitumen which is super heated to 210°C prior to digestion. The blend is digested for a minimum of 45 minutes and the maximum self life at spraying or mixing temperature is 6 hours. The blended CRB is either digested in the sprayer or a compartmented tank. Both the sprayers and compartmented tank have belly augers to agitate the CRB.
### Spray bar operating requirements for different binders

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>NOZZLE OUTPUT (l/min)</th>
<th>SYSTEM PRESSURE (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emulsion/Prime</td>
<td>7 – 9</td>
<td>100 - 150</td>
</tr>
<tr>
<td>Bitumen/PMB’s</td>
<td>13 – 15</td>
<td>150 – 200</td>
</tr>
<tr>
<td>Bitumen-Rubber</td>
<td>35 - 40</td>
<td>350 - 400</td>
</tr>
</tbody>
</table>

*Source: Kobus Louw*

### 3. Use of Polymer modified bitumen emulsions

Emulsions and polymer modified bitumen emulsions are used in various road construction and maintenance applications in RSA including:

- Dilute covers sprays on newly constructed spray seals to prevent early stone loss
- ‘Oil in water’ and invert emulsion primes for granular bases
- Tack coats and bond coats for ultra thin asphalt (without cutter)
- Rejuvenator and enrichment sprays for aged seals
- Construction of spray seals in winter especially Cape Seals
- Rut filling and texture treatments
- In-situ cold recycling of existing pavements
- Cold mixes using carbonaceous shale
- Cold pour crack sealants

Bitumen emulsion is ideal for labour enhanced construction and maintenance given that there is a big drive to create employment component of the works. This has lead to the popularization of certain road maintenance treatments such as the hand application of a thin surface texture treatment slurry prior to resealing and the applying of slurry by hand to fill the voids when constructing a Cape seal.

TG1 provides specifications which cover the use of PMBE’s in spray seals, bond coats, microsurfacings and crack sealants.

The PMBE’s used in RSA are 3 phase cationic emulsions systems which use SBR latex. PMBE’s are mainly used in winter to allow the construction of a seal on new or rehabilitated road to continue through out winter when road surface temperatures are as low as 10°C without disruption to the project. Limited resealing is done with emulsions.
Properties of polymer modified bitumen emulsions for various applications

<table>
<thead>
<tr>
<th>Properties of emulsion</th>
<th>Spray</th>
<th>Bond coat</th>
<th>Microsurfacing</th>
<th>Crack sealant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder content (%)</td>
<td>65 &amp; 70</td>
<td>65</td>
<td>62 – 65</td>
<td>55</td>
</tr>
<tr>
<td>Viscosity @ 50°C ( SF.s)</td>
<td>51 -200</td>
<td>21 – 100</td>
<td></td>
<td>&lt; 0.8 @ 25°C</td>
</tr>
<tr>
<td></td>
<td>51 – 400</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Properties of residue binder

<table>
<thead>
<tr>
<th>Softening point residue (min °C)</th>
<th>48 &amp; 55</th>
<th>48</th>
<th>48¹ &amp; 55²</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastic recovery @ 15°C on residue (min %)</td>
<td>50 &amp; 55</td>
<td>50</td>
<td>50¹ &amp; 55²</td>
<td>60</td>
</tr>
</tbody>
</table>

Source: TG1

Notes:
1. These are the requirements when the PMBE is use for an overlay
2. These are the binder requirements when the PMBE is used for rutfilling

Summary and recommendations

Given the similarity in traffic density and climatic conditions between RSA and Australia, the study group identified some opportunities for further investigation. It is recommend that adopting the following practices relating to binders for implementation:

- Increased use of field blended CRB for spray seals
- Use of wet blend CRB for asphalt wearing courses
- Use of PMBE’s for constructing spray seals in winter
- Making usage of dilute emulsions for cover sprays
- Making greater use of rejuvenation treatments to extend life of existing aged seals

The adoption of these practices could lead to more durable and longer lasting surfacings. To support these practices consideration should be given to make greater use of:

- high speed mixing blenders and digestion tanks with augers for producing CRB
- on-site measurement of CRB using a hand held viscometer to check compliance before use
- adoption of TG1 specifications for PMBE’s for spray sealing
- use of DSR to develop performance based specifications for binders across the temperature spectrum
- use of TG1 storage stability test to measure segregation of PMBs
Binders - Questions & Responses

B: Binders

Q 1. Does South Africa import bitumen yet? If not, why not?

In the past the supply of bitumen has exceeded local demand so RSA has always been a net exporter of bitumen into neighbouring states and the Indian Ocean Islands (150 – 200 ktpa). However they have experienced a sharp increase in local demand which has resulted in some stock outs during peak demand periods. Moves are afoot to investigate building dockside tankage which will allow them to import bitumen albeit at a premium price in comparison to the locally produced bitumen.

Q 2. Are penetration or viscosity graded binders used? Has any attempt made to link empirical properties to performance?

Bitumens are classified according to their penetration ranges but are also specified in terms of viscosity ranges at 60 & 135°C. The CSIR is currently investigating a new framework which will try link the binder properties over the temperature spectrum during its in-service life over time with performance.

Q 3. Are there different specifications for asphalt and sprayed sealing grades of road grade and modified binders?

Different grades of unmodified and modified binders are used for spray seals and asphalt. For example 80/100 is used for spray seals and 60/70 or 40/50 is used for asphalt. The same test methods are used to measure the properties of all the grades of refined bitumen although the values will differ. The same applies to all modified binders.

Q 4. Is any attempt made to compare to international grades of binders (Superpave Performance Grading)?

An attempt is being made under the auspices of the CSIR to develop a ‘simple’ performance grade specification which will render a seamless test regime across all types and grades of binders by using the DSR to specify properties on unaged, after RTFOT and PAV treatment.
Q 5. **What tests are used to evaluate the binder properties over the operational temperature spectrum especially at low in-service temperatures in seals?**

The following tests are incorporated in the binder specs:

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Unmodified bitumen</th>
<th>Modified binders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low temperature</td>
<td>nil</td>
<td>Elastic recovery properties are specified at 15°C for PMB’s</td>
</tr>
<tr>
<td>Intermediate temperature</td>
<td>Penetration @ 25°C</td>
<td>Resilience @ 25°C for CRB</td>
</tr>
<tr>
<td>High in-service temperatures</td>
<td>Softening point</td>
<td>Softening point</td>
</tr>
<tr>
<td></td>
<td>Viscosity @ 60°C</td>
<td>Flow @ 60°C for CRB</td>
</tr>
<tr>
<td>Elevated temperatures</td>
<td>Viscosity @ 135°C</td>
<td>Viscosity @ 165°C for PMB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Viscosity @ 190°C for CRB</td>
</tr>
</tbody>
</table>

Q 6. **Are cut-back binders used, if yes what percentage of the overall binder usage? Are there best performance guides for blending cutback in the field?**

Limited use is made of cutback bitumens. MC 30 which contains 45% cutter is used for priming granular bases. MC3000 which contains 12% cutter is used for grit reseals. Cutbacks are blended at the refinery and field blending is discouraged for safety and quality reasons.

Q 7. **What elastomeric and plastomeric modifiers are available? Does the specification identify them by type? What relative percentages of the modifiers are used?**

SBS is the most common polymer used for producing PMBs for spray sealing and asphalt wearing courses. Limited use is made of SBR latex in to produce hot spray sealing binders but is the main polymer used in modified emulsions. EVA is used in asphalt base courses.

Q 8. **Is crumb rubber (bitumen rubber) commonly used? In sprayed sealing? In asphalt? What percentage in each application?**

CRB is the most popular modified binder used on high trafficked roads for resealing and certain types of asphalt wearing course overlays. Its use is more popular in the dryer inland regions as there is a concern that it can trap water which is considered a potential problem in high rainfall areas.

800 thousand tons of CRB modified asphalt was used on the recent duplication of the main freeway system around Johannesburg. It is estimated that about 30 million litres of CRB is sprayed annually.
Q 9.  **How is crumb rubber included in sprayed sealing? Direct mixing in bitumen sprayers? Terminal blending and long distance hauling? Field blending at point of application?**

The crumb rubber is preblended with the bitumen in high speed mobile blenders close to the point of use. Sometimes it is digested in the sprayer before spraying otherwise a compartmented tank is used. Sometimes the CRB is transported to remote sites if it can be used within 6 hours before the properties degrade at elevated temperatures.

The use of CRB is also influenced by size and location of the project given the high establishment costs. Typically more than 1.5 million litres would be required to justify the establishment of a mobile blending unit on-site.

Q 10. **Does environmental benefit or sustainability enter into consideration in the selection of binders?**

Consideration is given to using locally produced crumb rubber from recycled tyres to save on importation of expensive polymers, assist with the disposal of used tyres and extend the life of the surfacing.

Q 11. **What efforts are being made to use alternatives to crude oil sourced bituminous binders? Are there binders commercially available?**

We did not come across the use of any alternative binders to bitumen excepted the limited use of Shell’s Mexphalt C coloured synthetic binder to demarcate a dedicated bus lane in Durban. The use of coal tar binders have also been discontinued due to environmental and health reasons.

Q 12. **What modified binders are commonly used in asphalt manufacture? Is the selection based on performance? Have long term performance trials been undertaken to assess the advantages?**

SBS and CRB are the most popular modified binders used for asphalt wearing courses whilst EVA is used mostly in base courses.

SANRAL makes exclusive use of modified binders to reseal their road network of 16 170 km. TRH3 Surfacing Seals for Rural & Urban Roads provides guidance for the selection of the most appropriate binders for given traffic and climatic conditions. TG1 provides additional guidelines for the selection of the most appropriate binder for a given stress condition and differentiates between the different modified binder classes currently available.

We did not come across any long term performance trials for monitoring modified asphalt.

Q 13. **Has accelerated pavement testing (HVS) been used to assess the performance improvements for modified and bitumen rubber for seal and asphalt? If yes, have the results been included in design guides?**

Modified binders have been included in HVS testing and the pavement performance included in the national and provincial design pavement design guides. Details are covered in the CSIR presentation by Benoit Verhaeghe and in Chapter 6 Question 5.
Q 14. Do specifications, test procedures and best practice guides exist for crumb rubber binders (bitumen rubber)?

TG1 contains specifications and test methods for CRB for use in spray seal and asphalt.

Sabita Manual 19 provides guidelines for the design, manufacture and construction of bitumen rubber asphalt wearing courses.

Q 15. What attempts have been made to improve the plastomeric properties of crumb rubber binders?

CRB modified asphalt by nature is elastomeric and this results in resilient modulus values @ 25°C of 1500 to 2500 MPa which is similar to SBS. Sasol indicated that they were doing work in Germany to produce a hybrid CRB with a polymer for use in asphalt.

Q 16. What attempts have been made to lower the handling temperature and improve the self life of crumb rubber binders?

CRB are sprayed and mixed at temperatures between 190 – 210°C. At this temperature the binder has a limited shelf life of up to 6 hours. To extend the self life the temperature must be dropped to 165°C so that it does not degrade over time.

Source: TG1
Q 17. What properties are required for rubber crumb?

The rubber crumbs must comply with the following grading and properties as specified in TG1:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>% mass passing screen:</td>
<td></td>
</tr>
<tr>
<td>1.18 mm</td>
<td>100</td>
</tr>
<tr>
<td>0.6 mm</td>
<td>40 – 70</td>
</tr>
<tr>
<td>0.075 mm</td>
<td>0 - 5</td>
</tr>
<tr>
<td>Poly-isoprene content (% mass)</td>
<td>25 min</td>
</tr>
<tr>
<td>Fibre length (mm)</td>
<td>6 max</td>
</tr>
</tbody>
</table>

Source: TG1

Q 18. How are modified binders specified? At what point are properties for modified binders applied? Point of manufacture or at the point they are delivered to site?

PMB’s are specified in accordance with the requirements contained in TG1. They are largely polymer blind and are based on meeting end binder properties. The properties must comply at point of usage. Suppliers are required to provide laboratory certificates tabling specific properties with each batch and the other properties on a frequency basis.

On large contracts a site laboratory will be established to measure the key binder properties such as softening point and viscosity. Samples will also be taken and sent for off site testing.

Q 19. How is segregation and degradation of modified binders controlled?

TG1 provides the following guidelines to manage and prevent degradation of PMB’s on-site:

- The tank should be designed with an appropriate circulation system to ensure that there is a constant movement of binder over the flues during heating.
- In the event of having to superheat the binder above 180°C it is essential that tanks are fitted with augers or stirrers to prevent localized overheating.
- Store the binder at the minimum pumping temperature and not at the application temperature.
- The binder should only be heated to the application temperature just prior to use to limit degradation of the polymer.
- Do not allow the binder to solidify in the storage tank as reheating will result in localised overheating around the flues. Rather heat the binder intermittently over an extended period to maintain a constant storage temperature.
- Avoid rapid heating of the binder. As a rule of thumb the rate of heating should not exceed 15°C per hour unless the tank is fitted with an agitation mechanism.
• All tanks are to be fitted with calibrated temperature gauges. In the case of a sprayer a temperature gauge should be fitted on the spray bar as well as the tank to ensure that the binder is sprayed at the correct application temperature.

• All established modified binder storage facilities should strive to install temperature recording devices with automatic temperature controls for heating.

• Obtain a method statement from the supplier on the correct handling and storage temperatures for the modified binder.

**Q 20. To what extent are emulsions used in sealing? Is there a push to use emulsions based on environmental reasons?**

Emulsions are use in various forms in the construction of seals. They are used mainly:

• For priming granular and crushed bases
• In the construction of spray seals in winter especially Cape Seals
• In slurries for texture treatments, rutfilling and slurry for constructing Cape seals
• For dilute covers sprays on newly constructed spray seals to prevent early stone loss
• For rejuvenator and enrichment sprays for aged seals
Q 21. What lab test method and limits are used to measure the storage stability and degradation of PMB’s?

TG1 specifies a 3 day storage stability test according to method MB – 6. The test requires that the PMB is stored in a glass tube at 160°C and the softening point is determined on the bottom and top third of the sample. The specification allows a maximum difference of 5°C in line with CEN requirements for this test.

TG1 also has a RTFOT requirement for monitoring change in the softening point before and after treatment of -2 and +8°C. This limit tends to cause problems for SBS modified binders as the softening points fluctuate over time for a given batch of binder.
**Q 22. Are high modulus asphalt technologies available? What lessons have been learnt in the acquisition of the necessary materials and skills to deliver the asphalt? Will the material be subjected to APT and is it likely to be included in the SA Pavement Design Method?**

The CSIR has successfully facilitated the transfer for the implementation of EME (French term for high modulus asphalt otherwise known as HiMA) technology from France using local materials. The first project using HiMA was placed while the study tour was in Durban at the entrance of the Port. The target is to design a mix with a high binder content of 6% which has a modulus of 14 MPa @ 15°C and does not crack. The key to HiMA is procuring a hard bitumen with a low penetration range of 10 – 20 dmm. This binder is available from both the refineries in Durban. The intention is to use HiMA to either increase the pavement design life or reduce the layer thickness of a full depth asphalt pavement by up to 30%. The current flexible pavement design life in RSA is only 25 years.

**Q 23. Is binder sampled at point of use for quality assessment? If so how, and what tests are undertaken?**

Binder samples are taken at during the supply chain and at the point of use for all large projects and tested on a frequency basis. Large spray seal and mobile asphalt contracts perform most of the tests on-site. TG1 provides details of the testing frequency required at point of delivery for modified binders.
For PMB’s the following samples are taken and the softening point tested:

- Manufacturer – each batch
- Hauler – each load
- Site storage tank – every day during production
- Sprayer – each load

For CRB a sample is taken and the viscosity is measured using a hand held viscometer before usage.
Reference Material
List the presentations or other material gathered during the tour.


2. SABS 308 specification for Road Grade Bitumen

3. Sabita manual 2: Bituminous binders for road construction and maintenance


5. Johan O’Connell CAPSA 11 paper ‘Adjusting the standard RTFOT procedure to improve the prediction of short term ageing’
6. IMPROVING PAVEMENT PERFORMANCE

**Working Group**
Leader: Jaco Liebenberg  Group: Russell Lowe, David Angell, Rob Vos

**Tour scope**
The focus under improving pavement performance was to investigate the methods of assessing pavement performance through modeling and accelerated testing leading to improved pavement design methods more closely linked to material properties. Consideration was also to be given to the use of foam and emulsion stabilized materials, high quality unbound granular bases and the introduction, through technology transfer, of high modulus bases to South Africa.

*Constructing the HiMA trial in eThekweni / Durban (Erik Denneman - Tour)*

**Feedback from**
- University of Stellenbosch – SANRAL Chair of Pavement Engineering
- SANRAL Head Office in Pretoria, Western Cape and KwaZulu Natal Offices
- Council for Scientific and Industrial Research
- eThekweni / Durban Municipality
- N3 Toll Concession
Observations

The observations address four areas, the South African pavement design system and its growth into a holistic materials and pavement performance design system. Their approach to “dedicated” funding for surfacing and pavement maintenance linked to the experience of the more commercial approach of SANRAL and some previous inadequate funding. Third is “pavement and asset management” which highlights the data collection linked to performance allowing rational management of funds and network asset risk. The last observation is on the propensity to innovate and accept new or improved technologies or systems.

1. The new South African Pavement Design System “Godzilla”

“Developing a holistic, comprehensive design system for surfacing and pavement layers embracing material properties, measured performance, proven experience and variable loading conditions”.

The current Mechanistic-Empirical Pavement Design System in South Africa, developed in the late 1970’s and early 1980’s with improvements in the 1990’s, was observed to have some shortcomings in recent years which generated a wide consensus in industry to upgrade and improve the system. The system was counter intuitive and provided, at times, unusable results and was regarded as too sensitive to the type and method of input leading to widespread loss of confidence in the current system.

Since its development, new technologies have been developed and additional knowledge has become available which prompted an update of the system. Field performance of Long Term Pavement Performance (LTPP) sections had been collected for many years and was more readily available. This made it possible to commence a process of recalibration of the existing damage and prediction models, including the possible development of new models.
A major objective of the updated design method was to bring theory much closer to observed performance. The decline of the level of expertise in pavement engineering in Southern Africa resulted in the introduction of younger and less experienced engineers into the field of pavement design. They were constrained by their lack of practical knowledge and experience to interpret complex pavement behaviour.

The updated system is attempting to capture the knowledge of experienced pavement designers and to incorporate it into the new design system. The goal of the system has to deliver results that are accurate (match reality) and are balanced with respect to the material selection, whether the pavement material be unbound granular, or bound asphalt materials / concrete or stabilised materials.

In May 2005 a task group was established to develop a framework of the updated design system and by November 2005 the Research and Development framework was available. The required research and development work covered a wide and diverse range of disciplines including:

- traffic loading predictions
- material resilient response
- pavement resilient response
- damage models
- probabilistic and recursive schemes
In November 2006 the Research and Development needs were defined in individual projects and were appropriated assigned to research institutions, industry of academic institutions.

The delivery program was divided into short term (12 to 18 months since inception), medium term (5 to 8 years since inception) and long term (8 to 12 years since inception) objectives.

The program involved the contribution of all major universities, research institutions, private sector and industry. Due to the formidable size of the challenge of the early stages of the project, it was nicknamed “Godzilla” reflecting the enormity and difficulty of the task. The project is being managed and driven by The South African National Roads Agency Ltd.

At the CAPSA’11 conference a number of papers were presented on the development of the system are referenced in this report. Typically Erik Denneman “Revision of damage models for asphalt pavements” and Hechter Thyse “Interim revisions of the South African mechanistic-empirical pavement design method for flexible pavements”

New design process will includes 3 different level methods – L1 simpler process for new professionals, L2 for experienced professionals and L3 for design specialists. In L1 & L2 some inputs will be assumed defaults. This involves a risk related approach and the more complex method is likely to be used in higher risk/more complex situations.
2. Funding of pavement maintenance

“Based on previously poor funding provision, road maintenance funds are now ring-fenced and locked-down in funding allocations. Formal maintenance management systems are required to measure and manage the network condition and motivate funding requests.”

The national road network, currently about 16 000 km and managed by The South African National Roads Agency Ltd. (SANRAL), is well funded with sound funding principles. The mechanism used to fund SANRAL includes government grants for non-toll roads and toll revenue from toll roads. SANRAL increasingly utilises the collection of toll to fund road upgrades and rehabilitation. Major road upgrades are not being implemented if the costs cannot be recovered from tolls. SANRAL funding to the network is controlled centrally within the agency with expenditure for periodic maintenance and pavement rehabilitation directed to the region(s) based on proven performance and justified needs, not on an equal geographical or provincial spread. Investment decisions are based on preventative maintenance and asset preservation needs and not just addressing the pavements at the terminal end of their life thereby avoiding the “worse first” funding trap.

When SANRAL was formed to look after the national network, the provincial (or state) network was allocated funding as part of the overall provincial budget. The competing demands, and in some cases corruption, at this level of government has resulted in serious problems with inadequate funding for road maintenance, well below the required levels, and a major deterioration in the provincial road network.

A new initiative to address this situation has been implemented where provinces will be required to have available, reliable and accurate network data less than 2 years old. With this in place
government, through SANRAL, will provide funding for pavement maintenance. The initiative is being developed and is expected to be commenced in the next budget cycle. This will prevent road maintenance competing for funding with departments such as education, health, etc. and is expected to address the deterioration and backlog of maintenance on the provincial networks.

3. Pavement and asset management

“Measure, predict performance and manage expenditure”

Pavement management systems, in their availability and functionality, vary greatly between roads authorities in South Africa. Currently SANRAL have network data, less than 2 years old, available on all their roads. This age of the data increases significantly and the amount available also decreases for provincial, metropolitan and municipal networks:

**Provincial networks**: data on 82% on the network, but most of the data is older than 10 years

**Metropolitan networks**: data on 64% on the network, but most of the data is older than 10 years

**Municipal networks**: data on 4% on the network, but most of the data is older than 10 years

Currently SANRAL is encouraging the collection of Pavement Management System data on provincial, metropolitan and municipal networks to assist in the management of these networks. In the case of a major metropolitan area with more than 5 million inhabitants data is collected on vehicle type and movement from mobile phone data and the vehicle registration database. This innovative approach enables SANRAL to evaluate the impact of changing toll charges and better
predict traffic diversions both for short-term events and on the longer-term redefinition of road user preferred routes.

On the SANRAL national road network, 65% of the pavements are older than 25 years while 75% are older than 20 years. This is generally beyond the initial pavement structural design life of the pavements. The network therefore requires careful management in order to spend the budget wisely, as experience has showed that:

- for a road in good condition that requires periodic maintenance (such as a repair and reseal), the cost is say x/km
- if the maintenance is deferred by 3 to 6 years, the cost to bring the road back to a good condition increased to 6x/km; and
- if the maintenance is deferred by 5 to 8 years, the cost to bring the road back to a good condition increased to 18x/km.

It is therefore important for SANRAL to time its maintenance such as to avoid unnecessary increase in maintenance costs due to inappropriately deferred maintenance.

SANRAL annually collects a range of data from its network. The data is then analysed and the performance of a pavement is predicted. A number of alternate treatments are modeled and their performance predicted. The identification, selection and priority of projects is based on the impact a particular treatment or deferral of a maintenance treatment will have on the overall life cycle cost of the pavement over an economic analysis period. The aim of this approach is to reduce the number of poor pavements that require large expenditure.

This approach compiles a master project list that is region blind and directs expenditure towards the section(s) of the network where maintenance will have the most significant impact on the preservation of the network asset.
Funding priorities are therefore set up to prioritise and first address maintenance needs that will result in the preservation of a section of pavement, and what is left over is then used to address the worst roads.

SANRAL use a range of off the shelf software such as dTIMS, HDM4, etc. with only the interfaces between the software developed in-house.

Achieving the highest performance of the road network also requires careful assessment of the traffic loading and the inherent risk of the materials being used. For this reason legal axle loads are effectively enforced with zero tolerance for offenders. Research is also supported to assess the consequences of increased tyre footprints and pressure. Legislation can do little to address this impact but the implication for network deterioration can be determined and built into tolling and maintenance funding need projections.

The application of sound engineering principles, along with asset management techniques, including measurement through efficient data collection of the long-term pavement performance, provides SANRAL with the ability to prioritise and manage its national network on sound investment, operational and commercial grounds. This approach is being extended to the provincial and larger municipal areas.

4. New technologies

“New approaches and innovative technologies are embraced, trialed and fully evaluated. If successful the innovation is implemented, if unsuccessful reasons are sought allowing for further trials or possible abandonment. Reflects an openness to seek better and more beneficial outcomes.”

A number of new innovative technologies are currently being researched that will improve pavement performance in general. These include the use of new materials, new pavement systems and the improvement of existing technologies.

HiMA (EME)

High Modulus Asphalt (HiMA) is an asphalt base with a very stiff, fatigue resistant binder and high binder content. It originated from France titled “Enrobe a Module Eleve” (EME) and initiatives are underway to transfer the knowledge, and the product performance, from France to South Africa. A large amount of effort is currently under way to facilitate this transfer of knowledge and to adapt the product for South African binders and conditions. The research also considered the performance of these mixes on a number of test sites in the UK.
HiMA trial site in eThekwini / Durban being inspected by the tour group

The implementation work has included Sabita, CSIR, SANRAL, Stellenbosch University, binder suppliers and asphalt manufacturers all contributing to a shared outcome for the introduction of HiMA. Research is on the mix design and structural pavement design was undertaken at the CSIR and University of Stellenbosch. This will be validated with field trials, and will be subjected to APT, LTPP and laboratory testing. The trial site at eThekwini / Durban was visited during construction.
Draft guidelines and specifications are expected once the validation process is complete.

The introduction of HiMA asphalt will also reinforce the concept of perpetual pavements allowing for even thinner pavements to be produced which do not exceed their crack initiation strains at the bottom of the layer.

Observations during the HiMA site visit and during discussion with eThekwini / Durban staff:

- HiMA is achieving up to 14000 MPa modulus
- The potential benefits of high rut resistance whilst maintaining good fatigue resistance is being confirmed in the test implementation – previous mixes all rutted quickly
- The design process is different and interesting – Denneman, Transfer of High Modulus Asphalt Technology to South Africa Figure 1

**Ultra Thin Concrete Surfacing**

Ultra thin concrete is a thin (60mm) layer of very strong (up to 100MPa compressive strength) concrete continuously reinforced with mesh and fibre, capable of handling large deflections and load repetitions. A number of APT tests have been conducted and a few test sections have been constructed that are now subject to LTPP evaluation. The technique is well suited to the South African conditions as it is constructed using labour based methods.

**Foam bitumen and Bitumen Emulsion treated materials**

Ongoing research to validate the damage models and resilient response models of the material. These are all included in the “Godzilla” project.

Research (Dave Collings, Long-term behavior of bitumen stabilised materials) into the long term behaviour of Bitumen Stabilised Materials, particularly material with net bitumen contents of less than 3%, indicates that the primary mode of failure, over the long term, is deformation similar to that of unbound materials rather than fatigue as previously assumed. Currently in South Africa, these materials are being modelled in two stage behaviour model, fatigue (pre-cracked) and post-
cracked phase, regardless of the net bitumen content. It is now becoming apparent that the behaviour of these materials across the two phases are more complex than for bound materials.

South Africa uses lower bitumen contents (1.7 to 2.5%, while Australia (2.5 to 4%) and New Zealand (2.5 to 3.5%) typically use higher net bitumen contents. It is appreciated that the behaviour of higher bitumen content materials may differ from that of lower bitumen materials, but the transition is banded and depends on a number of parameters.

A study by Twagira and Jenkins (The influence of temperature distribution and void characterisation on the durability behaviours of bitumen stabilised materials) found that deformation is dependant on the temperature distribution and void content within a bitumen stabilised layer. This may be of particular interest in the consideration of when to open a newly constructed layer for traffic and the possible effect it may have on the pavement performance. The void content has been found to influence the mechanism of heat transfer within the layer.

**Granular base layers (G1)**

High quality unbound base layer is not really considered a new technology in South Africa. It is well established, widely used and is very successful. New research into updating and improving the modelling of the resilient response, stress stiffening and damage models of the material are currently being done, also as part of the “Godzilla” project. Damage models for these types of materials have been in place and widely used since the late 1970's.

![Laying G1 base by paver](image)

High quality unbound base layers rely on a number of factors for its performance. These include:

- the selection of high quality durable rock;
- a very tight and controlled grading envelope required;
- good support, generally by means of a stabilised subbase layer or layers; and
- very high density.
Because of the nature of the material, specifying density in terms of modified AASHATO or Standard Proctor was not practical. Density are generally specified by either percentage Apparent Relative Density or Bulk Relative Density. Typical density for G1 type materials are 88% of Apparent Relative Density.

Experience in Southern Africa have shown that it is difficult to achieve these high densities without adequate support, hence the inclusion of stabilised subbase layers in the pavement system. By carefully controlling the properties and construction processes of the stabilised subbase layers, reflective cracking has been eliminated.

Comments on G1 base from Louw Kannemeyer were that it usually requires a CTSB (3-4% cement) 150mm thick; and the observation that its performance is not so good in areas with more than 1000mm annual rainfall as it will not stand water getting in from top or the sides.

New damage models, which include the stress stiffening and elasto-plastic behavior of the material are currently being developed as part of the Godzilla project. Further research into the addition of small quantities of bitumen emulsion during construction n to enhance the durability of material marginally in or out of specification are also ongoing.

**Certification of non-standard products**

Developed to match the advantages of the UK Highways Agency Product Assessment System (HAPAS) and the French Avis Technique methods of certifying non-standard products for the built environment. The system is managed by the CSIR and the Agrement Board of South Africa and has three relevant road construction products:

- Bridge deck joints
- Ultra Thin Friction Courses (UTFC)
- Cold mix patching materials

The system is based on the British Board of Agrement, assesses available historical data and track record including inspections of existing sites. Appropriate laboratory tests are conducted; trials and QC are witnessed leading to an interim certification. Installation trials are monitored for a period of two years after which a certificate to a given class of performance is issues. Continuous monitoring takes place.

**Ultra Thin Friction Courses**

Three products have been certified to the Agrement Board South Africa requirements and are being used in the country.

UTFC has a wide range of applications and fits well into the perpetual pavement concept. The 15 to 25mm thick high friction surfacing is placed upon a pavement structure of sufficient thickness to prevent bottom up cracking. The sole maintenance measure for that pavement is then the periodic removal and replacement of the UTFC.
UTFC is required to meet the performance matrix included in the following table from "Erik Denneman – Fit for purpose certification of road products" – Tour

UTFC has been successfully used in airport applications and SANRAL has endorsed its use on their major highways and airports. (Corne Roux - CAPSA, Pieter Molenaar “The development and performance of a new Ultra Thin Friction Course for OR Tambo International Airport in South Africa”)

<table>
<thead>
<tr>
<th>Section</th>
<th>Parameter</th>
<th>Test</th>
<th>Acceptable value</th>
<th>Indicative value</th>
<th>Proposed value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.6.1a</td>
<td>Aggregate Polish resistance</td>
<td>PSV test</td>
<td>50 [1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6.1b</td>
<td>Torque bond value</td>
<td>Torque bond test</td>
<td>≥ 400kPa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6.1c</td>
<td>Skid resistance</td>
<td>Grip tester</td>
<td>≥ 0.66</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Portable skid resistance</td>
<td></td>
<td>≥ 0.65</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SCRIM</td>
<td></td>
<td>≥ 0.55</td>
<td></td>
</tr>
<tr>
<td>3.6.1d</td>
<td>In service Texture depth</td>
<td>Sand patch method</td>
<td>0.6 mm</td>
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<td></td>
<td></td>
<td>SMTD</td>
<td>0.6 mm</td>
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<tr>
<td>3.6.1c</td>
<td>Resistance against moisture induced stripping</td>
<td>Wheel tracking tests</td>
<td></td>
<td>No stripping</td>
<td></td>
</tr>
<tr>
<td>3.6.1f</td>
<td>Aggregate Crushing Value</td>
<td>ACV test</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6.1g</td>
<td>Visual condition of pavement</td>
<td>TMH 9</td>
<td>Condition index ≤ 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6.1h</td>
<td>Permanent surface layer deformation</td>
<td>Wheel tracking tests</td>
<td></td>
<td>≤ 25% of layer thickness</td>
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<tr>
<td>3.6.1i</td>
<td>Durability (raveling)</td>
<td>Cantabro abrasion test (mass loss)</td>
<td>Unaged &lt; 35%</td>
<td>Aged report</td>
<td></td>
</tr>
</tbody>
</table>
Ultra Thin Friction Course nearing the end of its service life
Summary and recommendations

With road budgets more constrained than Australia, and with years in which the country was barred from access to international technology and new products, the South African pavement sector has developed quality local expertise.

The South African road network has the advantage of was very few subgrades less than CBR10, whether by design of by access to good quality materials. This influences, not only the depths of pavement structures, but types and options available as well.

This has resulted in a more nationally focused road sector, driven at national level with funding to ensure a commercially aware method of investing in, and managing, the road asset and network. SANRAL, the national road authority is constituted on commercial lines and collects toll funding and receives allocations from the Transport Department. This business awareness is driving the development of a pavement design system more linked to reality and based upon actual material properties and long term pavement performance data.

The approach is one of “measuring, modeling and managing” allowing for a knowledge based response to changes in traffic demand, funding or load increases. The approach, linked to service related KRA’s, has assisted the Provinces in having maintenance funds ring-fenced and pavement management tools used as the basis of allocation. Maintenance funds are aimed at “best for asset preservation” which will allow sections of the network to enter terminal states if inadequate funds are allocated for their maintenance.

The country has developed skills and expertise ranging from APT and long term pavement performance data collection to comprehensive modeling for pavement design systems. There is encouragement for innovation and new products are subjected to structured evaluation with the goal of achieving a good outcome.

In more recent years useful and appropriate international technologies have been identified, such as warm mix asphalt and high modulus asphalt, with the technology jointly transferred by road authorities, researchers, consultants and the asphalt and binder industry.

To facilitate the introduction of non-standard products a system similar to the French Avis Technique and the UK HAPSA has been developed to manage and certify the introduction of “fit for purpose” road products. This system has allowed for the development and use of Ultra Thin Friction Courses some of which has been in use for its full product cycle.

Recommendations:

1. Maintain contact with SANRAL on the development of the SAPDM to identify possible advantages for Australia
2. Drive to have road network asset management run on commercial lines or at least on business principles where KRA’s are designed to provide service to the road user and inadequate funding can result in road deterioration or closure.

3. Encourage the use of the performance data to allocate funds reserved for asset preservation and maintenance.

4. Promote the benefit of LTPP linked to APT and the advantage that it brings in pavement modeling and asset & budgetary management.

5. Promote the use of beneficial improvements in materials, pavement structures and management systems including the use and development of:

   - Non-standard certification of “fit-for-purpose” products
   - High Modulus Asphalt
   - Ultra Thin Friction Course proprietary / certified products
   - Warm Mix Asphalt
   - Lower binder content bitumen stabilized materials
   - High density granular bases
Improving pavement performance - Questions & Responses

Q 1. What is Godzilla and is it likely to spread to other countries? Feedback on this clearly a big and ambitious project and its links to performance records, wider range of engineering references testing and use in full pavement & surfacing performance would be valuable!

See observation #1 provides a detailed discussion on this.

*Gerrie van Zyl – Towards improved understanding of seal performance - CAPSA’11*

*Johan Gerber – Seal modeling and design - Revision of the South African Pavement Design Method - Tour*

The South African Pavement Design Method is also being expanded to include the structural impact of different seals on the pavement structure and its performance. The research from the “Godzilla” project is widely published and it is expected to be used in other countries.

*Hechter Theyse – Interim revision of the South African mechanistic-empirical pavement design method for flexible pavements – CAPSA’11*

Q 2. Is fatigue Endurance Limit concept to be included in South African Pavement design?

Fatigue endurance is not yet incorporated into the South African Pavement Design. However research into this is included in the “Godzilla” project. A value of around 65με is generally considered to be appropriate.

Q 3. Is the “perpetual pavement concept” of value and is the international efforts on this likely to impact on pavement thickness design?

The “Perpetual pavements” thinking is considered to have value, but is still a new concept in South Africa, although some of its principles may have been introduced on some pavements locally. It is likely to have an influence in pavement thickness’s for pavements in the upper spectrum of traffic volumes (> 100 million ESAL) and for airport pavements.
Q 4. **What accelerated pavement testing is being undertaken? How is it input into current design models? Are there links to international APT facilities? Are there links to the NCAT test track?**

At the CSIR facilities in Pretoria the Heavy Vehicle Simulator (HVS) was inspected on the study tour CSIR (Benoit Verhaege). The HVS was seen in operation at the terminal end of testing on Ultra–Thin reinforced concrete pavement test bed. Also previously run HVS test beds containing granular pavement configurations (IE G2 Bases) were inspected.

Accelerated pavement testing research includes:

**Rigid Pavements**

- Structural design
- Ultra-thin reinforced concrete
- Fibre–reinforced concrete
- Roller–compacted concrete

**Flexible Pavements**

- Stabilisation technology
- HMA grading optimisation
- HiMA technology
The output from the HVS test results since the 1980’2 has been included in the performance models used in the SAPDM. The past HVS performance data, linked to Long Term Pavement Performance information has been used to develop catalogue designs for various pavement structures and pavement materials. The availability of the HVS promoted the adoption of new materials including LAMBS (large Aggregate Mixes for Bases), G1 bases and Bitumen Stabilised Materials (BSM). The APT device, and the experience gained overtime, allowed the pavement designers to better link new pavement data to practice. This approach has also allowed the sharing of experience and performance data where the Californian HVS was used to evaluate crumb rubber asphalt with the results confirmed in South Africa.

South Africa has established international links with many institutions and organisations involved in APT research. An International HVS Alliance has been established and a comprehensive HVSIA Activity Matrix.

The details and benefits experienced through the South African heavy vehicle simulator and accelerated pavement testing in covered in details by Benoit Vehaeghe’s presentation on “Overview of the CSIR’s activities” which includes the weblink (www.hvsia.co.za) to the Heavy Vehicle Simulator International Alliance which links the activities of South Africa, Germany, USA (Florida, California, US Army), India, Sweden and China.

Other research programs are in place utilising smaller scale APT test units such as the MMLS unit located at Stellenbosch University (Prof Kim Jenkins) and at CSIR (Dr Erik Denneman).
Q 5. Has the investment in APT improved the performance of the South African road network? Explain.

APT (most notably the Heavy Vehicle Simulator) probably have contributed more significantly to the knowledge and understanding of pavement behaviour in Southern Africa than generally realised. Studies with the HVS managed South African pavement engineers to understand the behaviour of pavement systems, including the interaction between layers, the behaviour of individual layers and materials, failure mechanism and the behaviour of pavements and materials when subject to moisture. The knowledge on the performance and behaviour of granular, cement stabilised and bitumen (foam and emulsion) stabilised materials are most notable.

Based on the presentation to the tour by Benoit Verhaeghe of the CSIR the following observations were made about the use and benefits of HVS – APT works.

Benefits of HVS programme:

- Better Understanding and modeling
  - Minimises under design (premature failures prevented)
  - Minimises overdesign (most cost-effective solution)
- Fills the important gap between lab design and true field pavement behavior
- Allows better (optimal) use of funds and natural resources

Q 6. Are high modulus asphalt technologies available? What lessons have been learnt in the acquisition of the necessary materials and skills to deliver the asphalt? Will the material be subjected to APT and is it likely to be included in the SA Pavement Design Method?.

High modulus Asphalt (HiMA) technologies are not yet widely available in South African and is currently moving from local research to confirm the performance through full scale local trials. Lessons learnt up to date include the difference in specifications and test methods from France which can not always be interpreted on the same basis or directly compared to existing technologies and information available in South Africa. Trial sections are being constructed and some will be subjected to APT testing with the findings flowing into the subsequent structural design method.
Q 7. **How have you managed to calibrate local test methods with the French EME mix design methods? Have you established equivalent test values for fatigue and wheel tracking performance?**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
<th>Result</th>
<th>SA equivalent test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workability (Gyratory compactor)</td>
<td>Max 6% voids after 100 gyrations</td>
<td>5.7 %</td>
<td>Gyratory</td>
</tr>
<tr>
<td>Durability (Duriez test)</td>
<td>Retained strength: &gt;0.7</td>
<td>0.9</td>
<td>Modified Lottmann</td>
</tr>
<tr>
<td>Rutting (Wheel tracker)</td>
<td>Rut depth after 30 000 cycles &lt;7.5 mm</td>
<td>5.2 mm</td>
<td>RSST-CH, Wheel tracking</td>
</tr>
<tr>
<td>Beam dynamic modulus</td>
<td>15 °C-10 Hz: &gt;14 GPa</td>
<td>17 GPa</td>
<td>Beam or cylinder dynamic modulus</td>
</tr>
<tr>
<td>Fatigue (Prism)</td>
<td>με for $10^6$ fatigue life: &gt;130</td>
<td>90 με</td>
<td>Beam fatigue</td>
</tr>
</tbody>
</table>

**French mix design – to SA**

The process of calibration of French test methods with South African methods is advanced and some calibration has been achieved. The amount of data to successfully calibrate is still relatively small and the process is ongoing. Indicative values for fatigue and rut resistance has been established, but is still subject to further local testing and will be confirmed by APT and LTPP sections. Most of the calibrations were done by duplicate testing of mixes using more than one test method and parameters.

Q 8. **What parameters have you used to obtain the required properties for EME bitumen ie Penetration Index etc?**

EME bitumen testing parameters are geared at the higher viscosity grades of “hard” bitumens which are produced through special refinery production processes. These hard bitumen grades were specified in EN 13924:2006 which comprised two grades with penetration specified in the order of 15 to 25 and 10 to 20 with post RTFO Retained Penetration set to 55 and above. The Softening.
Point of the hard binder was set between 55 and 71 degrees with Post RTFO bitumen expected to be greater or equal to than the original SP value minus 2 degrees. The corresponding Viscosity range for 15 to 25 grade bitumen is greater or equal to 550.

**Q 9. What is the local experience with regards to early life skid resistance and permeability of SMA? Do you apply grit and how do you prevent ingress of water into the pavement? What are your permeability and texture requirements?**

The availability of the Agreement South Africa certified Ultra Thin Friction Courses has reduced the use of generic SMA with the functional benefits replaced by the properties of the UTFC.

There does not appear to be any early life skid resistance issues for SMA mixes in South Africa and, where needed, they have wet weather advisory signage on the high speed national toll roads to reduce the traffic speed in wet conditions for all road surfacing types including concrete. The surface texture and PSV of the SMA are monitored to ensure satisfactory performance under heavy traffic.

There have been some minor concerns with achieving compaction where rubber bitumen SMA mixes have been placed however concerns on the permeability of the SMA in general has not been raised. The underlying asphalt pavements have not been reported to have been damaged by water infiltration through the SMA surfacings.

Gritting is not specified for SMA surfacings at present however work is being done on the national road network with skid resistance assessment by SCRIM testing. It is unclear

Unable to determine if permeability of the SMA has caused underlying pavement problems and there is no requirement for waterproofing seal to be used under the SMA to address water ingress into pavements.
Q 10. What are your mix design and field compaction requirements for BTB?

BTB mix design requirements in Southern Africa is currently similar to that of HMA (e.g. Marshall, etc.). Field compaction requirements are generally 97% - voids of MTRD (RICE) with the aim of having around 7 to 8% field voids. BTB is the also the “common name” used for the COLTO 26mm dense graded asphalt. This material is produced to full asphalt criteria for aggregates, binder volumes and field compaction and relies on the larger aggregate size to keep the bitumen content between 4 and 4.5% by weight. Only very view crushers produce this material without fractionation and re-blending. The COLTO specification also makes provision for an asphalt with a 37mm sized aggregate commonly called LAMBS (Large Aggregate for Bases), this also is an engineered asphalt requiring careful design and production. As for the 26mm stone size the binder content is dropped to below 4%.

As such the BTB title used in South Africa is not that as used for the upgrading of large aggregate sized “run of crusher material” with percentages of bitumen generally below 4%.

Q 11. How are high performance thin asphalt surfacing specified and tested for compliance? Has the Agrement system been implemented and how has it been accepted by the Industry?

<table>
<thead>
<tr>
<th>Table 7: Effect of pavement structure on UTFC performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition 2011</td>
</tr>
<tr>
<td>Failed</td>
</tr>
<tr>
<td>Signs of failure</td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>Pavement Structure</td>
</tr>
<tr>
<td>2005: UTFC</td>
</tr>
<tr>
<td>1979: 13/6.7 Double seal</td>
</tr>
<tr>
<td>110 G3</td>
</tr>
<tr>
<td>150 C3</td>
</tr>
<tr>
<td>150 G5</td>
</tr>
<tr>
<td>150 G6</td>
</tr>
<tr>
<td>2005: UTFC</td>
</tr>
<tr>
<td>1987: 13/6.7 Double seal</td>
</tr>
<tr>
<td>150 C1</td>
</tr>
<tr>
<td>150 C4</td>
</tr>
<tr>
<td>300 G6</td>
</tr>
<tr>
<td>2006: UTFC</td>
</tr>
<tr>
<td>1994: 19 Cape seal</td>
</tr>
<tr>
<td>150 G1</td>
</tr>
<tr>
<td>150 C4</td>
</tr>
<tr>
<td>300 G7</td>
</tr>
<tr>
<td>ADT–Combined</td>
</tr>
<tr>
<td>8620</td>
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<tr>
<td>8620</td>
</tr>
<tr>
<td>3212</td>
</tr>
<tr>
<td>ADTT</td>
</tr>
<tr>
<td>1106</td>
</tr>
<tr>
<td>1106</td>
</tr>
<tr>
<td>384</td>
</tr>
<tr>
<td>Deflections (Avg. max.)</td>
</tr>
<tr>
<td>2005: 518</td>
</tr>
<tr>
<td>2008: 674</td>
</tr>
<tr>
<td>2005: 478</td>
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<td>2008: 562</td>
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<td>2005: 473</td>
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<td>2008: 494</td>
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<td>Base Layer Index</td>
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<td>2005: 245</td>
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<td>2008: 338</td>
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<td>2005: 235</td>
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<tr>
<td>2008: 265</td>
</tr>
<tr>
<td>2005: 215</td>
</tr>
<tr>
<td>2008: 257</td>
</tr>
</tbody>
</table>

From the below paper of Corne Roux

Ultra Thin Friction Courses (UTFC) asphalt are generally specified a propriety product and require certification (Agrement in South Africa). The specification is performance based for the first three
to five years depending on the project with performance guarantees required to be provided which is then released at intervals of 1, 2, and 3 (or 1, 3 and 5) years.
Refer to Observation 4 for details of the product and its functional specification.

The CAPSA’11 paper “Critical review of performance of UTFC in South Africa – Corne Roux” provides insights into the evaluation and appropriate use of UTFC with the caution that it requires a sound base with limited deflection if it is to perform to expectations.

Q 12. **What key pavement evaluation tests for network level evaluation? Is Ground Penetrating Radar being used? Are standard network level tests undertaken across the South African network or are the results assessed differently in each of the Provinces? Are there differences between the approaches used for urban networks vs non-urban?**

GPR is acknowledged as an investigative tool but is not routinely employed for network level analysis by the major road agencies. Cited reasons for its non-use were the difficulties if calibration and data interpretation.

A paper presented at CAPSA’11 Terence Milne “Road management data assimilation and quality control of asphalt and bituminous pavements using GPR” presents and overview of the status of new developments in antennas and the opportunities for the use of GPR in southern Africa.

Q 13. **What methods are used to avoid/delay reflection of underlying asphalt cracking when resurfacing/overlay with asphalt? What results are achieved?**

No formal methods are available in design manuals or guidelines, but generally Asphalt reinforcement (geogrids, etc.) has been quite successful. An asphalt reinforcement guideline document are available and included as draft TG3: Asphalt Reinforcement Guide which covers the types available, their function and benefits, design methods and practical construction issues.

Q 14. **Is pavement maintenance funded nationally? And if so, what basis is used nor allocation of pavement repair funding in non-national jurisdictions? Does this have an impact on the overall level of service of the roads?**

From 2012 yes, but between 1994 and 2011 it was funded provincially for provincial roads and nationally for national roads (SANRAL). This resulted in provincial roads competing for funding with other departments such as education, health, etc. and generally received funding level way below what is required to retain network condition. New legislation is currently being considered that from 2012 will re-introduce national funding for road maintenance nationally and provincially. The process will be managed by SANRAL, but executed by provinces on provincial roads and SANRAL on national roads.
Network condition for State, Provincial, Metropolitan and Municipalities

(Louw Kannemeyer)

This funding arrangement has had the consequence of significant deterioration of the road network before funding was allocated for intervention. This later than optimal investment for the provinces has resulted in the ring-fencing of their funding to address the back log of maintenance and the reconstruction of significant lengths of roads.

Q 15. Does the economic development value of road infrastructure enter into the provision of roads and the pavement types / structures selected?

Currently this is only done regularly on national roads and more specific on project level. Life cycle cost, including future economic costs, are considered in the selection of appropriate pavement type and rehabilitation strategy on national roads.

Work was done by Sabita in the early 2000’s to evaluate the social benefits of increased mobility and the provision of reliable transport access to underprivileged and remote areas. The approach has been accepted and is considered when macro planning activities are undertaken but is not yet embedded in the relative comparison of different road projects. Refer Sabita Information Sheet #10 – Asphalt and Society

Q 16. What relative amounts of foam and emulsion stabilised base courses are used? Are there performance & design models available? What development work is being undertaken? Are there clearly different applications for emulsion vs foam stabilisation?

Bitumen contents in foam and emulsion treated materials are generally less than typically used in Australia. Net bitumen contents of between 1.5% and 2.5% is common with higher bitumen contents not that common. Some extensive research, which include full scale APT, have been conducted to understand and describe the behaviour and failure mechanism of these materials and performance models are available. Research in South Africa has shown that there appears to be little difference in the performance and behaviour between foam and emulsion treated materials, with the main difference being the method of application. However, the same research has also indicated that some materials favour foam while others favour emulsion.
Q 17. **What new concepts and pavement performance options are under research?**

New concepts currently being researched includes among others:

- probabilistic and recursive modelling
- low volume roads
- energy and emissions for road construction and rehabilitation

**Q 18. What sustainability and CO2 reduction drivers exist in the roads sector and how are they being evaluated and addressed against pavement performance? Are trade-offs permitted for reduced performance but improved sustainability? (use of lower standard materials, recycled waste materials etc)**

This question is addressed through the Sustainability chapter.

Currently product comparisons are undertaken including the amount of energy consumed in production and maintenance as well as the CO2 generation of the alternates. This has not yet been embedded in the decision making process of the road agencies.
The industry is also evaluating its energy footprint and options for CO2 reduction across its operations the findings are captured in the *Sabita: Implication of the Proposed Carbon Tax Legislative and Policy Framework on SABITA members – February 2011*.

**Q 19. Do they consider maintenance minimisation in the road design especially in the design and construct type contracts?**

No, generally not. The lowest life cycle cost approach is more favoured, even in DF&C contracts. However the maintenance capability of the asset owner is considered when selecting the appropriate materials for the project. Typically a high risk (thin) surfacing would not be selected if the road authority had limited maintenance capability.


**Q 20. How do they approve asphalt mix designs and what is their process of validation?**

Asphalt mixes are being assessed per project. No asphalt mix certification schemes are in place and each project certifies the mix for use on that project. Validation are generally through specified performance testing which may includes rutting, fatigue, moisture susceptibility, permeability, etc.

For the domestic and municipal markets asphalt suppliers produce a range of products complying with local standard mixes or COLTO mixes adapted for municipal conditions (generally increased binder contents). The local government sector has an asphalt specification which was developed in conjunction with Sabita.

**Q 21. What is the South African approach to managing skid resistance?.**

Skid resistance is currently being measured regularly only on national roads. Data are entered into a database, together with the other PMS data recorded and the road are flagged if a problem is detected with skid resistance. The main mechanism to manage skid resistance is in the selection of high quality aggregate and to prevent the use of surfacing aggregate that have a polishing potential as far as practically possible. Where this is not possible, skid resistance will be monitored closely and resurfacing interventions may be scheduled earlier.

The minimum PSV for aggregates in the COLTO specification is 50 for SMA, continuous & gap graded asphalt and rolled in chippings, 45 for gap graded surfacing. The Engineer (Superintendent) is authorized to accept lower PSV aggregates.

Reference: *COLTO specification*
Reference Material

List the presentations or other material gathered during the tour.

1. Asphalt Academy, draft TG3: Asphalt Reinforcement Guide
2. Benoit Verhaeghe, Overview of the CSIR’s activities, presentation September 2011
3. COLTO Specification for asphalt
5. Dave Collings, Long-term behavior of bitumen stabilised materials (BSMS), CAPSA’11
6. EM Twagira, The influence of temperature distribution and void characterisation on the durability behaviours of bitumen stabilised materials, CAPSA’11
7. Erik Denneman, High Modulus Asphalt T2, presentation September 2011
8. Erik Denneman, Fit for purpose certification of road products, presentation September 2011
9. Erik Denneman, Revision of damage models for asphalt pavements, CAPSA’11
10. Gerrie van Zyl, Towards improved understanding of seal performance, CAPSA’11
11. Hechter Theyse, Interim revisions of the South African mechanistic-empirical pavement design method for flexible pavements, CAPSA’11
13. Louw Kannemeyer, SANRAL Asset management overview, presentation September 2011
15. Kim Jenkins, HiMA and EME, presentation September 2011
16. Pieter Molenaar, The development and performance of a new Ultra Thin Friction Course for the OR Tambo International Airport in South Africa, CAPSA’11
17. Sabita Information Sheet #10 Asphalt and Society
20. Terence Milne, Road management data assimilation and quality control of asphalt and bituminous pavements using GPR, CAPSA’11
7. SUSTAINABILITY

**Working Group**
Leader: Rob Vos
Group: David Angell, Trevor Distin, Russell Lowe

**Tour scope**

**Sustainability** – recycling, warm mix asphalt, efforts to reduce carbon footprint, carbon calculators and the impacts for road asset management

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*Cold in-plant manufactured Bitumen Stabilised Material using Recycled Asphalt – eThekwini / Durban*

**Feedback from**
Krishna Naidoo,, Dave Collings,Tony Lewis, Saied Solomons, Kim Jenkins

**Observations**

Sustainability was an underlying issue for each of the four centres visited and was included in the CAPSA 2011 conference theme Roads of the Future and in the conference focus areas:

- Reducing energy consumption in the construction of bituminous layers
- Reducing the impact of road building activities on the environment
- Designing for extended performance of asphalt
- Flexible pavement systems for extended life
- Meeting the needs of society
Observations are drawn from the papers presented both from a South African perspective and from the international participants.

**Green Circle Road – from rehabilitation to failed pavement and back – the road materials bank**

During the visit to the eThekwini Municipality / Durban there was clear focus on the need for sustainable use of materials, this included the policy of the 100% reuse of all municipal materials and “waste”. This included the concept of the “Green Circle Roads” where the municipality is the owner of the network, the road, and the residual pavement materials. When rehabilitation is required, it considers the deconstruction of the asset and its engineered and managed reuse, reducing the introduction of virgin materials to a minimum and tracking the most beneficial path for the reuse of the materials from design through to project completion.

Industry too was approaching the impact of carbon taxation which provided a matching spur to promote lower energy consumption and awareness of ways to improve the energy efficiency of manufacturing asphalt. Through Sabita’s reporting and information at the CAPSA’11 conference the costs, savings and investment returns for various efficiency improvements and CO2 reduction measures where detailed. The proactive approach to identifying the impacts of the Carbon Tax and early identification of remedial measures will simplify the process of change for the South African members of Sabita.

1. **The road is a reusable materials bank**

The concept of the road network as a reusable materials store or bank, changes the philosophy on recycling and reusing all the materials within the road. Once within the “roads bank” the materials should be tracked and not lost into waste or lower standard use!
The primary goal is to achieve the lowest cost life cycle reuse, lowest CO₂ generation followed by obtaining or retaining the maximum service from the given material. This means a high quality, high value road building material such as asphalt is reused as asphalt and in an attempt to reduce the carbon footprint this is done by the lowest energy means.

Typically recycling asphalt into hot mix asphalt is the norm, but energy reduction through using Warm Mix Asphalt technologies with high RAP contents is a better path. There was work described at the CAPSA’11 conference in Europe which sees the temperature of asphalt production with high RAP contents well below current temperatures.

![Image: Lower energy pavements: Cold-in-plant recycling]

Krishna Naido – low energy pavements – recycling from the road materials bank.

The general approach to sustainability is therefore through optimizing the reuse of existing pavement materials within the roads bank, through recycling and dropping the energy costs in its processing. Whilst RAP is recycling the material back to it’s for original quality standard, the use of BSM bitumen stabilized materials takes existing granular materials and improves their properties to provide longer pavement life through higher engineering than the original granular material.

Sustainability driven approaches to improve the use of RAP are:

- Reuse of existing granular bases through cold in-situ recycling and adding bitumen or emulsion as a stabilization agent. The existing seal and/or asphalt surface is remixed with the granular base to form the new base course which is overlaid with a new asphalt wearing course.
- Recycling of RAP cold in-plant with foamed bitumen for reuse as road base on low trafficked residential streets
- Recycling of RAP in the manufacture of new asphalt both as a base course or wearing course. The limitations on the amount of RAP used will largely depend on RAP
availability and plant capability on the proviso that the new asphalt with RAP will meet the specifications requirements of all conventional asphalt.

Likewise for granular materials, improved crushing and placement controls allows a very dense base course G1 to be produced which also improves the engineering performance of the granular raw material. For hot mix asphalt the use of HiMA provides a similar performance increase where the higher strength, ductile bitumen allows for the same structural capacity with lower thickness, reducing the need from granular materials. HiMA with RAP further promotes the roads materials bank concept where even higher standard products can be created from materials already in the bank.

2. Warm Mix Asphalt Introduction

The introduction of WMA has been embraced by the industry in conjunction with one of the largest Metro Council and not the Provincial or National Roads Agencies. The driver is to provide more sustainable solutions for road provision to the benefit of the community which they serve than the public at large.

Krishna Naido – Warm Mix Asphalt trials leading to the Sabita WMA guidelines

The strategy adopted was to start by minimising the risk and once more experience has been gained push the envelope to the next level of broader introduction. This included field trails on low trafficked roads by reducing the temperature to 20 to 30 degrees Celsius first, then the incorporate increasing amounts of RAP followed by utilising polymer modified binders.

This work is detailed in the Questions: Warm Mix Asphalt and refers to the newly released Sabita Manula 32: Best practice guideline for warm mix asphalt which addresses the production and construction of WMA. The WMA project included as participants industry, road authorities, academia and consulting engineers allowing for broad review and acceptance.
3. Assessing the Carbon Tax implications

On behalf of its members, Sabita undertook a review of the need to reduce green house gases and to conserve energy looking at three key areas. These were 1) the legislation and policy framework on carbon emissions, 2) the cost implications of a carbon tax and. 3) carbon reduction strategies for hot mix asphalt production.

The findings are included in a Sabita publication “Implementation of the proposed carbon tax legislative and policy framework on Sabita members” and a CAPSA’11 paper by Oliver Stoko “Energy and related carbon emission reduction technologies for hot mix asphalt plants”.

The findings are based on a carbon tax starting at R75 (A$9) per tonne of CO2 to R200 (A$24) which are evaluated against a base plant configuration of 100 tonnes per hour or 180 000 tonnes per year. The spilt energy sources for plant production was assumed at 3% diesel fuel, 12% electricity, 25% burner fuel (to remove water) and 60% burner fuel (for heating) which included the estimated 0.3 to 0.35 GJ/ton of asphalt produced. The CO2costs for the that range for the standard 100 tonne / hour plant was estimated at between R 1 056 000 (A$127 765) and R 1 234 000 (A$ 149 302) per annum, equating to A$0.71 to A$0.83 per tonne.

Remediating and carbon reduction measures to reduce the production of CO2 were assessed and compared and included:

- Stockpiling aggregates under roof on sloped concrete floors
- Counter-current flow design of burner gas and aggregate flow direction in single drum plants
- Frequent replacement of worn flights in the drier
• Effective lagging of all vessels and pipelines containing heated materials
• Tighter control of feed air for combustion and reduction of flue gas heat loss
• Asphalt products storage in closed silos
• Conversion of hot mix asphalt operations to warm mix asphalt operation
• Burner fuel switch from HFO to natural gas
• Use of batch plants for applications requiring large product diversity

**Summary and recommendations**

Sustainability and Carbon Tax implications are global issues which provides the opportunity for Australia to learn for the steps taken in South Africa. A number of the initiatives are similar in both countries, such as increasing use of RAP and the introduction of WMA. Most of the key learnings would be conceptual of nature although there are clear directions on the sustainability benefits for the use of HiMA and UTFC.

Prime concepts are the preservation position of the “road as a materials bank” followed by open awareness of the relative energy and CO₂ implications of our day to day business. Continuing to provide and maintain the roads component of the transport and mobility network will experience increasing challenges to past principles and we need to be sensitive and prepared to respond.

**Recommendations**

1. Promote the sustainability concept of the “road materials bank” where construction materials in the road network remain in the bank and are sustainably management, improved and reused.
2. Evaluate and report on the legislative and policy implication of the Australian Carbon Tax on road construction, surfaced seals and asphalt production.
3. Identify and share carbon reduction strategies for road surfacing and asphalt manufacturing in Australia.
4. Promote the sustainability credentials and benefits of road building materials including:
   • Recycled Asphalt Pavements including cold in-place, cold in-plant and Warm Mix Asphalt
   • Bitumen Stabilised Materials for improving granular material properties
   • Warm Mix Asphalt as a temperature reducing, asphalt worker friendly and energy efficient asphalt product
   • Ultra Thin Friction Courses for the preservation of high standard surfacing aggregates
   • High modulus asphalt Hi MA for reducing pavement thickness and saving on construction materials used in the pavement
   • Bitumen Rubber binders for their role in reducing the environmental impact of used motor car tyres
   • Very long life or perpetual pavements (>50 years) where bottom up cracking of asphalt pavements is eliminated and long term maintenance requires only renewal of the wearing course
Sustainability - Questions & Responses

RECYCLED ASPHALT PAVEMENTS

In South Africa the term Recycled Asphalt (RA) is used to describe recycled asphalt pavement, this is acronym is similar to European practice where RA refers to “reclaimed asphalt”. Pavement is exclude to remove any potential for the inclusion of underlying granular material from the recycled asphalt and allow for the reuse of asphalt waste.

In 2009 the industry and road authorities produced an excellent reference publication under the Technical Recommendations for Highways series TRH 21: 2009 Hot Mix Recycled Asphalt which provides information on the recycling process, the availability, preparing & stockpiling, mix design procedures, plant requirements, QC, economic and OHS&E considerations.

Most major asphalt works are undertaken to the COLTO Series 4000: Asphalt pavements and seals, Section 4200: Asphalt base and surfacing, this document is included in the references, and details the requirements when recycled asphalt is used.

Asphalt recycling is considered in four possible processes:

- Cold in-place recycling, generally using foam or emulsion in predetermined quantities and then overlaid with a new bituminous wearing course.
- Cold in-plant recycling, RA carted to a specialised mixing plant where foam or emulsion is added in a continuous process. The material is either paved or spread & shaped with at motor grader and compacted, then overlaid with a new bituminous wearing course.
- Hot in-place recycling, heated in place, scarified, lifted and remixed with the addition of virgin aggregates, bitumen or rejuvenating agents. Then paved and compacted as for conventional asphalt. This process is not currently used in South Africa anymore.
- Hot mix asphalt recycling, combined with new aggregate and binder in a mixing plant to produce a recycled mix, which satisfies standard specifications for hot mix asphalt.
Questions (1, 2, 3, 13)

Q 1. What percentages of recycled asphalt is used in South Africa? Estimated tonnage? Does it vary by urban / regional and by Province.

In the 80’s to 90’s significant qualities of RA was used on project work including use as sub base to concrete pavements. This dropped off in the late 90’s with the total of RA as a percentage of new HMA estimated at 5% in 2005. The increased cost of raw materials and the relatively higher cost of bitumen resulted renewed attention with the publication of the TRH21 in 2009.

The use of RA in South Africa is limited by its availability. Most road pavements and surfacings consist of granular layers with thin bitumen seals. Thick asphalt pavements are limited to major metropolitan areas, their major connecting highways and in some of the major airports. In the metropolitan areas the RA is included at percentages generally around 5 to 15% depending on availability. Most projects where RA is available will have that either stockpiled for future works or included in the mix for that project.

The total production of asphalt is South Africa is approximate 4.5 million tonnes which at the 2005 RA % would equate to 225 000 tonnes annually.

Q 2. What percentages of RAP are allowed in wearing course, binder course and base course?

The use of RA is permitted in the most widely used specification, COLTO Series 4200: Asphalt base and surfacing which provides not limits on the percentage of RA permitted in hot mix asphalt. The specification does require that the asphalt meets all the specification criteria and conforms to additional handling and QC criteria. This includes the evaluation of the RA, testing frequencies and stockpiling requirements.

TRH 21 provides a range of permitted amounts as per Table 8.5

<table>
<thead>
<tr>
<th>Type of layer or mix</th>
<th>% RA of new HMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wearing course:</td>
<td></td>
</tr>
<tr>
<td>- SMA</td>
<td>Less than 3</td>
</tr>
<tr>
<td>- Polymer modified medium graded</td>
<td>12</td>
</tr>
<tr>
<td>- Unmodified medium graded</td>
<td>18</td>
</tr>
<tr>
<td>Binder course</td>
<td>23</td>
</tr>
<tr>
<td>Base course</td>
<td>27</td>
</tr>
</tbody>
</table>

In practice each project is evaluated against the amount of RA available and the maximum percentages that can be included in the mix. When RA is fractionated into aggregate sizes the proportions of the resulting RA will vary in residual binder content and this will influence the maximum percentages in Table 8.5.
The introduction of Warm Mix Asphalt Technologies using foamed bitumen, organic waxes, surfactants & zeolites and has seen the inclusion of higher percentages of RA in all layers due to the less hardening of the bitumen with the lower mixing temperatures and improved coating achieved. This has particular relevance to wearing courses.

For cold in-place and cold in-plant recycling 100% of the existing material is reused with the addition of foamed bitumen or bitumen emulsion. Whilst not currently used in South Africa anymore, hot in-place recycling makes use of only small additions of virgin aggregate resulting in very high percentages of RA in the final pavement.

Q 3. Are their restrictions on the use of modified binders in RAP? Are their restrictions on the use of RAP in modified binder mixes?

RA from asphalt including EVA and SBS modified binders is permitted and is not considered a problem for recycling. Additional care is recommended in the preliminary mix design stage when using this RA in excess of 30%. RA that is derived from bitumen rubber modified asphalt should be treated with extra caution where the RA content exceeds 15%.

There is no guidance given or specific exclusion in the use of RA in modified binder mixes. In discussion with South African practitioners less that 15% RA is added to modified asphalt mixes which continue to achieve the mix design criteria.

Q 13. How do they manage RAP from milling of the City &Urban projects? Is SANRAL or Sabita (members) responsible for transport, storage and processing of RAP?

The ownership of RA varies by project and jurisdiction. Typically the RA is preserved for use by the road authority and then made available for inclusion in given projects. The evaluation and subsequent processing of the RA is undertaken as part of the project development and execution. The Sabita hot mix asphalt producers collect and process RA for incorporation into normal asphalt operations as percentages varying from 5 to 15%.

Recycling and in-plant foam stabilization – eThekwini / Durban Municipality

In the example of the eThekwini / Durban municipality the RA (and other reusable construction material) is planned and managed from project inception to material usage, with the pavement management system used to monitor and manage the value / status of the materials. The council
collects, stockpiles and self processed the RA directly into cold in-plant RA which is stockpiles and used for routine maintenance and smaller municipal projects.

**RECYCLED MATERIALS**

Work was undertaken in the 90’s where available waste products were considered for incorporation into asphalt. This work included glass and dune sand resulting in a *Sabita Manual 18: Appropriate standards for the use of sand asphalt*. With the introduction of large scale recycling, and reuse of glass in metropolitan areas, its commercial value rose and was no longer cost effective for use in asphalt as a substitute for the sand fraction.

**Questions (###5, 15)**

**Q 5.** *Are recycled waste materials (glass, concrete, brick, sulphur etc ) permitted for use in asphalt? If yes, what proportions and what applications?*

Where the waste sand is available sand asphalt is a popular domestic use product.

Larger municipalities have incorporated crushed concrete and broken brick into road construction mostly in non-bound layers. Successful trials have been undertaken with labour enhanced construction of penetration macadam using these materials and emulsions but no large scales works have been undertaken.

The eThekwini / Durban municipality manages the reuse of all its construction materials ensuring they are reused at the highest possible engineering property value of the material.

At the CAPSA’11 conference a paper “*Asphalt mixtures with waste materials: possibilities and constraints – Martin van der Ven*” reflected experimental work in the Netherlands on the inclusion in asphalt of sintered granulate from burned domestic waste, plastic domestic waste, domestic waste, ceramic waste from electrical insulators and foundry sand. There was no one silver bullet although the ceramic waste held the most promise for use in asphalt in base layers.
Another paper reconfirmed the value of steel slag in asphalt “Conversion of an industrial waste into a value adding asphalt ingredient – Gunnar Winkelmann”

Extensive use has been made of modifying bitumen with ground recycled rubber from tyres for use in both asphalt and spray sealing. Weathered steel slag has also been used successfully in heavily trafficked seals and asphalt surfaces.

Steel slag aggregate used with bitumen rubber on the heavily trafficked N3 highway near Harrismith

**Q 15. Are recycled or waste materials being used for sealing aggregates?**

This is not done at present although the use of the coarse part of a fractionated RA was considered a possibility.
CARBON FOOTPRINT

South Africa has a carbon tax on emissions implemented on new motor vehicles level of CO₂. At this stage a carbon tax does not apply to the road construction or road product sector. There is a general awareness of the impact carbon tax / pricing will have on the selection and use of bituminous and other products. Much of the drive to use emulsions, warm mix asphalt technologies, increased percentages of recycled asphalt and bituminous stabilized materials (BSM) has been to meet environmental objectives which today match the goal of CO₂ reduction.

In discussions it was clear that there was an awareness of the embedded energy aspects, energy per tonne of competing products and the CO₂ outputs for products and construction processes.

<table>
<thead>
<tr>
<th>Carbon Reduction Measure</th>
<th>Capital Cost (R)</th>
<th>Savings (R/year)</th>
<th>PP (years)</th>
<th>PP with carbon tax (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRM1: Storing fine aggregates under roof</td>
<td>830 000</td>
<td>450 000</td>
<td>1.9</td>
<td>1.6</td>
</tr>
<tr>
<td>CRM2: Co-current to counter-current drum</td>
<td>880 000</td>
<td>200 000</td>
<td>4.5</td>
<td>4.0</td>
</tr>
<tr>
<td>CRM3: Regular flight replacement</td>
<td>63 000</td>
<td>66 000</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>CRM4: Effective lagging of vessels/pipelines</td>
<td>245 000</td>
<td>220 000</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>CRM5: Tighter feed air control to drier</td>
<td>250 000</td>
<td>330 000</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>CRM6: Asphalt product storage</td>
<td>285 000</td>
<td>55 000</td>
<td>5.2</td>
<td>4.6</td>
</tr>
<tr>
<td>CRM7: Conversion of HMA to WMA plant</td>
<td>1 300 000</td>
<td>960 000</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>CRM8: Fuel switch from HFO to natural gas</td>
<td>400 000</td>
<td>190 000</td>
<td>2.1</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4 253 000</strong></td>
<td><strong>2 471 000</strong></td>
<td><strong>1.7</strong></td>
<td><strong>1.5</strong></td>
</tr>
</tbody>
</table>

Sabita has commissioned a study to measure and identify mitigation measures to help members reduce their energy consumption in the manufacture of asphalt in anticipation of the Governments plan to introduce a carbon tax. The carbon reduction measures and payback periods were reported in a CAPSA paper by Oliver Statko entitled ‘Energy and related carbon emissions reduction technologies for HMA plants’ and Implication of the Proposed Carbon Tax Legislation and Policy Framework on SABITA members.

**Question (#4, 6, 7, 8, 14)**

Q4. **What sustainability and CO₂ reduction drivers exist in the roads sector?**

Client driven expectations of reduced environmental impact and societal expectations of sustainable industries are the major influences.

Sabita has reviewed the cost and CO₂ generation implications for the production of hot-mix asphalt which for an asphalt plant producing 100 tonnes / day (180 000 tonnes p.a.) would be in the worst case scenario be in the order of A$0.83 per tonne.

As in Australia, the cost shifting that will occur as a result of a carbon tax is being considered in the establishment of new plant and equipment. South African Government discussion papers
“Reducing Greenhouse Gas Emissions: The Carbon Tax Option” consider Long Term Mitigation Scenarios include carbon taxation and emissions trading.

It is not expected that South Africa will lead with significant application on carbon pricing until required by its major trading partners. Sabita has modeled the introduction of the carbon tax, scaling from about A$9 to A$24 per tonne and including the relative cost and benefits of carbon reduction measures in the manufacture of hot mix asphalt.

Short term taxation options will likely impose costs on the more affluent parts of the economy not servicing or being funded directly by the state. Direct levies on fuels are considered most likely followed by tax or levies on electricity production.

Q 6. Are carbon footprint and CO₂eq calculators being used? If yes, which ones?

No formalized road authority endorsed position was presented. There is an awareness of the metric but its application has not been fixed.

Sabita is also undertaking through TRL the calibration of the Asphalt Pavement Embodied Carbon Tool (asPECT) with software expected to be available to its members by early 2012.

Q 7. Are there CO₂eq reduction initiatives in the purchase of bituminous surfacings or asphalt pavements?

None were mentioned by the roads agencies consulted, although the general awareness in the likely future carbon pricing is resulting in project evaluations including the carbon footprint when evaluating alternatives.

Papers at CAPSA’11 covered the topic: “Combining LCC and energy consumption for enhanced decision making regarding rehabilitation options – Kim Jenkins” included the energy involved in the provision and maintenance of four alternate pavement types over a 20 year life and 30m ESA. The use of discounted live cycle costs and actual energy costs presented an alternate view of the
re-use and functional deterioration of pavement materials. Lower initial costs did not equate to lower life cycle costs when the environmental factors were considered.

Other papers on reducing energy consumption included the use of High percentages of RA in double drum mixes, WMA in South Africa and Low Emission Asphalt in Europe.

Whilst not directly linked to CO₂ reduction initiatives, South Africa makes extensive use of bitumen rubber (crumb rubber) binders in its spray seals and asphalt. It is considered a high performance modified binder with beneficial environmental outcomes through the use of rubber from vehicle tyres which are an environmental headache to dispose of. Whilst not specifically “mandated” as in certain USA states, the sustainability advantages draw string support from the asset managers when meeting their environmental objectives.

Q 8. Do road asset management policies include carbon reduction? What initiatives are in place to reduce any impact?

As indicated under Q4 and Q7 there is general commitment to sound environmental management in practices which, by nature, will result in carbon reduction. However no formal asset management policies focused on carbon reduction in the road authorities.

Table 1: Current and Future Sustainability Enhancing Implementation at ORTIA (Pretorius et al, 2009)

<table>
<thead>
<tr>
<th>Standard Product Base Values for 10 Year Projects</th>
<th>Combined Advantages of Selected Innovative Products Technologies</th>
<th>% of Standard Product Base Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rehabilitation cost ≈ R500 million</td>
<td>R101 million lower cost</td>
<td>20% lower</td>
</tr>
<tr>
<td>New Project Costs ≈ R1 000 million</td>
<td>R222 million lower cost</td>
<td>22% lower</td>
</tr>
<tr>
<td>Aggregate usage ≈ 1.5 million tons</td>
<td>0.5 million ton reduction</td>
<td>33% lower</td>
</tr>
<tr>
<td>Binder usage ≈ 5 000 tons</td>
<td>16 500 ton reduction</td>
<td>22% lower</td>
</tr>
<tr>
<td>Fuel usage ≈ 12 000 tons</td>
<td>2 600 ton reduction</td>
<td>22% lower</td>
</tr>
<tr>
<td>CO₂ usage (or Tree Equivalents for CO₂ Neutralising) ≈ 36 000 tons</td>
<td>8 000 ton reduction</td>
<td>22% lower</td>
</tr>
</tbody>
</table>

*Innovative products/technology includes Recycled Asphalt, High Modulus Asphalt, Foamed-based Warm Mix Asphalt on shoulders, Recycled Asphalt (100%) wearing courses and long life pavement technology.

The CAPSA’11 paper “The performance of environmentally beneficial asphalt products: practical case studies at OR Tambo International Airport over the last 5 years – Jannie Grobler”. The goal was to address the policy position of the Airport Company of South Africa – no risk to ACSA, reduction in capital expenditure, maximize recycling of existing materials and reduction of CO₂ emissions. The approach was to make use of sustainable resource enhancing alternate products covering:

- Recycled asphalt
- High Modulus Asphalt (HiMA)
- Carbon black modified mixes
- Perpetual Pavements / Long Life pavement technology
Also planned for later incorporation were:

- Foam based warm mix asphalt
- Ultra thin friction courses

**Q 14. SMA has longer life than DGA & OGA and less carbon footprint where are they up to with SMA selection and design and specification development and use?**

Stone Mastic Asphalt was introduced into South Africa in the mid 1990’s and was used on major roads as a wearing course with high resistance to rutting and good skid resistance.

With the introduction of specialised asphalt surfacing mix in the 1999 under the generic name Ultra Thin Friction Course (UTFC) there has been a reduction in the use of SMA. UTFC is a thin (18mm to 25mm) thick functional wearing course which has superior riding quality and skid resistance properties.

No comparisons carbon footprints appear to be used in the selection of asphalt wearing courses.

Feedback received during contact with the CSIR included a presentation on the development of a HAPAS type accreditation system for the purchase of proprietary products “Fit for purpose certification of road products – Erik Denneman”, This system operates under the auspices of Agrement South Africa based at the CSIR and provides fit for purpose certification of non-standard products – currently covering bridge deck joints, UTFC and cold mix patching materials. This system has facilitated the wide spread use of UTFC.
The performance of UTFC in South Africa was reported to CAPSA “Critical review of performance of UTFC in South Africa – Corne Roux, Dennis Rossmann, Louw Kannemeyer”. Key findings were:

- Performance of UTFC on structurally sound pavements was proven, with raveling as the eventual terminal distress mode.
- Successfully used as a rut filler in combination with the surfacing layer.
- Improvements in riding quality attained.
- No marked decrease in macro surface texture, average in-service values 1.1 to 1.5 (Fig 1)
- Was not the ideal product for use in “holding actions” on cracked pavements or pavements with poor support.
- Performance as a waterproofing layer was dependent on adequate tack coat application.
WARM MIX ASPHALT

Warm Mix Asphalt trials and temperature profile of the WMA mat during compaction

South Africa embarked on a structured evaluation of Warm Mix Asphalt technologies spearheaded through the eThekwini Municipality with support from Sabita, its members and the staff of SANRAL. The findings have been captured in a newly released guideline document the Sabita Manual 32: Best practice guideline for warm mix asphalt.

This document was not available for inclusion in this report which references is a copy of the draft version of the manual. The guideline includes chapters on:

It also includes an annexure “Interim specification for Warm Mix Asphalt base & surfacing” which is framed to match the SANRAL supported COLTO Specification series. A copy of the guideline will be available from the Sabita website (www.sabita.co.za).

Question (#9, 10, 11, 12)

Q9. Is warm mix asphalt and low energy asphalt being routinely used? What implementation strategy was used to introduce and evaluate the WMA performance?

Not routinely used, so far about 15 000 tonnes have been placed under trialing conditions undertaken over three years under industry and road authority supported project in eThekwinin / Durban area. Outcomes reflected in the Sabita Manual 32: Best practice guideline for warm mix asphalt.

The CAPSA’11 conference paper “Warm mix asphalt – the South African experience – Krishna Naidoo” covers the testing strategy leading to the wide acceptance of WMA. Three trials were held from 2008 to late 2010 encompassing RA in 10%, 20%, 30% and 40%, polymer modified binders, four different WMA technologies and 10 surfacing & 8 base mixes.

Presentation “Discussions with Australian Delegation – Progress with WMA – Tony Lewis”
Q10. What warm mix asphalt technologies are in regular use?

As in most countries there are a wide range of WMA technologies available. The trials in Durban included a number of technologies. The extent of market penetration is unknown, trial WMA technologies were:

- Rediset WMX - blend of surfactants and short chain polymers
- Sasobit – organic “bitumen flow modifier”
- Sasolwax Flex – technology concept of co-modified SBS and Sasobit modified bitumen
- NA Foamtec – water-based (1.5 to 3% by mass of binder) injected at high pressure into hot bitumen in an expansion chamber.

Q11. What compaction criteria are used for testing warm mix asphalt samples to check compliance for air voids?

The compaction criteria are as for dense graded asphalt. All asphalt mix designs in South Africa are confirmed through field trials of production, which then confirms the target requirements.

Q12. What changes have been made to hot mix asphalt specifications to accommodate warm mix asphalt?

A “stand-alone” specification has been developed based on the COLTO 4200 titled “Interim specification for warm mix asphalt base and surfacing”. This is included in draft form with the Sabita guideline of WMA.
Reference Material

List the presentations or other material gathered during the tour.

1. Andre Molenaar, Design of recycled asphalt mixtures using a double drum mixer, CAPSA’11
2. Asphalt Pavement Embodies Carbon Tool (www.sustainabilityofhighways.org.uk)
3. COLTO Section 4200: Asphalt base and surfacing
5. Erik Denneman, Fit for purpose certification of road products, presentation September 2011
6. Ettiene M. le Bouteiller, Bitumen emulsions: beyond pavement preservation, CAPSA’11
7. Francois Olard, Low emission & low energy asphalts for sustainable road construction: the European experience of LEA process, CAPSA’11
8. Gunter Winkelmann, Conversion of an industrial waste into a value adding asphalt ingredient, CAPSA’11
9. Jannie Grobler, The performance of environmentally beneficial asphalt products: practical case studies at OR Tambo International Airport over the last 5 years, CAPSA’11
10. Kim Jenkins, Combining LCC and energy consumption for enhanced decision making regarding rehabilitation options, CAPSA’11
11. Krishna Naido, Warm Mix Asphalt in South Africa, CAPSA’11
12. Martin van der Ven, Asphalt mixtures with waste materials: possibilities and constraints, CAPSA’11
13. Matthias Nolting, Construction of high quality asphalt wearing courses with more than 90% reclaimed asphalt (RA): a case study, CAPSA’11
14. Oliver Stoko, Energy and related carbon emission reduction technologies for hot mix asphalt plants, CAPSA’11
15. Sabita, Best practice guideline & specification for Warm Mix Asphalt, draft version 3
16. Sabita, Implementation of the proposed carbon tax legislative and policy framework on Sabita members, Feb 2011
19. TRH 21: 2009 Hot Mix Recycled Asphalt
20. Tony Lewis, Discussion with Australian Delegation – Progress with WMA, presentation September 2011
8. GENERAL

Working Group
Leader: All Group: Rob Vos, Kym Neaylon

Tour scope
Extracted from the brochure – include the SHSSA and CAPSA’11 outcomes

Feedback from
• Provide details

Observations
The following section provides the delegates observations from three groups in the USA.

1. First observation
Varied response from DOT depending on location e.g. State, and depth of experience with WMA

2. Second observation
Subheading if needed
• Granite constructions use WMA on most municipal works, and some Caltrans works
• Granite sees the main benefit as workability (increased window of compaction) and improved productivity
• Granite have held WMA (foam) for 24 hours in hot storage bins without issues arising
• Granite believe that WMA with 25% RAP result in a binder with similar characteristics as to a virgin hotmix binder (RTFO aged binder)
• Granite believe the largest risk is going overboard with RAP in WMA — the need to increase it slowly and manage the moisture content of the RAP.

3. Observations number 3

Summary and recommendations

A couple of paragraphs, which will be taken into chapter 3 along with the observations

- Transverse and fatigue cracking were observed more often in some pavements with RAP compared to pavements with all virgin materials

- Differences in cracking performance for several locations may have been due to higher dust contents and/or lower asphalt contents
General - Questions & Responses

MAIN HEADING 1 (i.e. Bitumen)

It is recommended that the questions in Chapter 9 are grouped into common topics and then addresses.

Question set 1? (#1, 4, 7, 9)
Write out the reframed question as combined into the set
- Response drawn from the presentations or answers given
- As many paragraphs as needed
- Include diagrams, photos or relevant slides

Question set 2? (#2, 5, 6, 21)
Write out the reframed question as combined into the set
- Response drawn from the presentations or answers given
- As many paragraphs as needed
- Include diagrams, photos or relevant slides

There could be over 20 question sets!!

MAIN HEADING 2 (i.e. PME)

It is recommended that the questions in Chapter 9 are grouped into common topics and then addresses.

Question set 1? (#1, 4, 7, 9)
Write out the reframed question as combined into the set
- Response drawn from the presentations or answers given
- As many paragraphs as needed
- Include diagrams, photos or relevant slides

Question set 2? (#2, 5, 6, 21)
Write out the reframed question as combined into the set
- Response drawn from the presentations or answers given
- As many paragraphs as needed
- Include diagrams, photos or relevant slides

There could be over 20 questions
Reference Material

List the presentations or other material gathered during the tour.

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9. APPENDICES

9.1 Detailed Itinerary
9.2 Tour Participants
9.3 Questions from Australia for the Study Tour
9.4 South African Acronyms, State Abbreviations, Conversions & Quotes
9.5 References
The tour travelled across the USA where contact was made with leading researchers at Universities of California Davis and Berkeley, Illinois and the University of Auburn, National Centre for Asphalt Technology, staff of State Departments of Transport of California, Virginia, North & South Carolina, Texas, the Federal Highways Administration, Asphalt Pavement Association of California and Californian Asphalt-Pavement Association, Virginian Asphalt Association, the National Asphalt-Pavement Association, Astec Inc, Banks Construction, Reid Construction and Granite Construction.
CAPE TOWN / STELLENBOSCH

Saturday 4 September 2011
5:00pm – 6:00 pm  Depart for Sheraton Grand Hotel, Sacramento
7:00pm  Dinner in Downtown Sacramento – McCormick & Schmicks, 1111 J Street
with Caltrans, UCPRC and Industry

Sunday 4 September 2011
5:00pm – 6:00 pm  Depart for Sheraton Grand Hotel, Sacramento
7:00pm  Dinner in Downtown Sacramento – McCormick & Schmicks, 1111 J Street
with Caltrans, UCPRC and Industry

Monday 5 September 2011
8:00 am – 9:30 am  Tour coach from Handlery Union Square hotel, San Francisco for UC Davis
University of California Pavement Research Center (UCPRC)
UC Davis Advanced Transportation Infrastructure Research Center (ATIRC)
9:30 am  Greeted by hosts John Harvey & Dave Jones
Participants:
UCPRC:  John Harvey, Dave Jones, Jon Lea, others?
Caltrans:  Nick Burmis, Joe Holland, Cathrina Barros, Kee Foo, Haiping Zhou
Industry:  Rita Leahy, Tony Limas, Brandon Millar
10:00 am  UCPRC Overview (John Harvey)
WMA (Dave Jones, Cathrina Barros, Tony Limas, Brandon Millar)
12:30 pm – 1:30 pm  Lunch at UC Davis ATIRC
1:30pm  Porous Pavements (Dave Jones)
Noise (Quiet Pavements) (John Harvey)
Pavement Management System (John Harvey, Jon Lea, Joe Holland)
High-RAP Mixes (Tony Limas)
5:00pm – 6:00 pm  Depart for Sheraton Grand Hotel, Sacramento
7:00pm  Dinner in Downtown Sacramento – McCormick & Schmicks, 1111 J Street
with Caltrans, UCPRC and Industry

Tuesday 6 September 2011
7:30 am  WMA/RAP group leaves Sheraton Grand Hotel, Sacramento
8:00 am  WMA/RAP group proceeds to Tony Limas, Granite Construction Plant

JOHANNESBURG / PRETORIA

Tuesday 6 September 2011 (continued)
12:30 pm – 1:30 pm  Perpetual Pavements – National Perspective (Rita Leahy)
Perpetual Pavement s - California I-710 – General Overview
CAP4RS & QC/QA Sampling – General Overview
Appendix 9.1 - Detailed Itinerary

5:45 pm – 6:15 pm  End of session – Tour coach to dinner – Spenger’s Fresh Fish Grotto.
Caltrans, UCPRC & Industry invited to join
AAPA tour for dinner

8:30 pm – 9:00 pm  Tour coach to Radisson Bay Front Hotel, Brisbane, CA

Wednesday 7 September 2011
8:30am – 9:30am  Tour coach from Hotel to Turner-Fairbanks Highway Research Centre
9:30-9:45 a.m.  Welcome from FHWA/NAPA/VAA (Pete Stephanos, Mike Acott, Richard Schreck)
   • Review of Agenda – Newcomb
4:00-5:00 p.m.  Mechanistic Design and Perpetual Pavements
   • Mechanistic Design – Harold Von Quintus
   • Perpetual – Dave Newcomb
   • High Modulus Base – Trenton Clark
6:00-8:30 p.m.  Dinner at Neyla, 3206 N St NW (near Wisconsin Ave.), Washington DC 20007

Thursday 8 September 2011
8:00 am  Travel to Richmond, Virginia
10:00 am  Meeting at VDOT (Chief Engineer & Trenton Clark), organised by Richard Schreck VAA
   Travel to VDOT Materials Dept Conference venue
   Visit WMA & RAP sites in Virginia – travel by tour coach
5:00 pm  End of meetings & site visits including SMA rehab projects
6:00 pm  Dinner with invitations to participants VDOT, VAA
   – travel to after dinner in Richmond to Washington hotel by tour coach

DURBAN

Thursday 8 September 2011 (continued)
3:47pm – 5:00 pm  Arrive Chattanooga – US Air flight 2547
6:00 pm  Coach from hotel to Fairyland Club Restaurant atop Lookout Mountain
6:30 pm  Welcome to Astec………………………………………..Ben Brock
7:00 pm  Dinner, return afterwards to Hotel by tour coach

Friday 9 September 2011
7:30 am  Tour coach from Hotel to Roadtec
7:45 am – 8:45 am  Tour Roadtec Manufacturing
8:45 am  Depart Roadtec for Astec
9:00 am – 10:00 am  Tour Astec Training Center & Manufacturing
4:30 pm – 5:30 pm  Visit WMA & RAP job site City of Chattanooga June 2007 – tour coach
5:30 pm  Tour coach, return to Hotel
6:30 pm  Dinner Downtown, Chattanooga, TN travel by tour coach

Saturday 10 September 2011
Some tour participants will travel directly to NCAT (PP & APT / NCAT group)
The WMA & RAP group proceeds as below:
8:00 am Travel in Astec aircraft to Monroe, SC
To Boggs Construction in supplied transport

Sunday 11 September 2011
11:30 am Travel to by bus to Asphalt Plant & Crushing Plant site – Jefferson, SC
12:00 pm Lunch at plant site
12:45–2:00 pm Overview of Asphalt Plant Drew Boggs
Tour Asphalt Plant
Overview of Crushing Plant
Tour Crushing Plant

CAPSA’11

Sunday 11 September 2011 (continued)
2:00p Return to Airport – transport supplied by Boggs Construction
2:30 pm Depart for Charleston, SC in Astec aircraft
3:30 pm Travel from Charlestown, SC to Banks Construction - transport provided
Overview Reid Banks, President, Banks Construction
Tour Asphalt Plant & RAP Fractionating Plant
Tour Lab Randy Funderburk, Lab Manager
5:00 pm Return on provided transport to airport & depart in Astec aircraft for Auburn
5:00 pm* Arrive Auburn travel by Tour Coach to Auburn University hotel
5:30 pm* Arrive Auburn University Hotel (refer to Alabama stop itinerary)

Monday 12 September 2011
7:30 am WMA & RAP group to airport {travel details see Tennessee}
PP & APT / NCAT group depart by coach for Atlanta and NCAT
12:30 pm Arrive Auburn midday – book into Auburn University Hotel
2:15 pm Arrive at NCAT office
5:00 pm AAPA group depart for hotel by coach

Tuesday 13 September 2011
7:30 am WMA & RAP group to airport {travel details see Tennessee}
PP & APT / NCAT group depart by coach for Atlanta and NCAT
12:30 pm Arrive Auburn midday – book into Auburn University Hotel
2:15 pm Arrive at NCAT office
5:00 pm AAPA group depart for hotel by coach

Wednesday 14 September 2011
7:30 am WMA & RAP group to airport {travel details see Tennessee}
PP & APT / NCAT group depart by coach for Atlanta and NCAT
12:30 pm Arrive Auburn midday – book into Auburn University Hotel
2:15 pm Arrive at NCAT office
Appendix 9.1 - Detailed Itinerary

5:00 pm — AAPA group depart for hotel by coach

**Thursday 15 September 2011**

9:00 am — Mixture Performance Testing ——— Nam Tran
10:00 am — break
10:15 am — WMA Research and Field Evaluation Projects ——— Andrea Kvasnak
11:15 am — NCAT Test Track Overview ——— Buzz Powell
12:30 pm — Depart for the NCAT Test Track by coach

**KNP**

**Thursday 15 September 2011 (continued)**

3:00 pm — Depart for NCAT office by coach
3:30 pm — Perpetual Pavement Design Concepts and Case Studies ——— David Timm
4:30 pm — Adjourn for the day, return to the hotel by coach

**Friday 16 September 2011**

8:30 am — Check out, Depart hotel in coach
8:45 am — Arrive at NCAT
9:00 am — Increasing RAP Contents in Asphalt Mixtures ——— Randy West
10:00 am — Other Issues including tour through lab for WMA & RAP group
11:00 am — Collaboration and opportunities
12:00 pm — Lunch break
1:00 pm — Travel by coach NCAT Auburn to Atlanta airport
4:50 pm — Departure from Atlanta on American Airlines flight to Dallas then to Los Angeles
11:20 pm — Depart Qantas QF Los Angeles for Sydney / Brisbane

**Saturday 17 September 2011**

8:30 am — Check out, Depart hotel in coach
8:45 am — Arrive at NCAT

**Sunday 18 September 2011**

8:30 am — Check out, Depart hotel in coach
8:45 am — Arrive at NCAT

**Monday 19 September 2011**

8:30 am — Check out, Depart hotel in coach
8:45 am — Arrive at NCAT
Appendix 9.2 – Study Tour Delegates

David Angell
Regional Manager, Asset Services
Brisbane City Council
2 Millennium Boulevard, CARINDALE, Q 4127
P: +617 3407 1470 M: +61 422 455 644
M: david.angell@brisbane.qld.gov.au

Why on tour: Interested in SA approaches to pavement design, asphalt surfacings (materials & design), WMA, ultra thin surfacings, use of RAP, foam bitumen stabilisation, reducing carbon footprint. Particular interest relates to urban areas.

Background: 18 years with Main Roads Queensland including construction, geotechnical, pavement research & development of design & analysis procedures & manual. 5 years with Brisbane City Council managing roads & drainage infrastructure maintenance & rehabilitation. BE (Civil), MEngSci (Highway), MBA

Robert Busuttil
Supervising Surfacing Engineer
Department of Transport, Energy & Infrastructure
Government of South Australia
19 Bridge Road WALKLEY HEIGHTS, South Australia 5098
P: +618 260 0544 M: +61 418 847 570
E: robert.busuttil@sa.gov.au

Why on tour: Interested how South African agencies manage their spray sealed network in terms of specification, selection and application of treatments. Keen to understand the bitumen supply situation. Make and maintain contact with local practitioners

Background: 15 years with Dept Transport South Australia including two years in pavement construction and 18 months with ARRB Group. The remaining time have been involved with provision of spray sealing advice and training.

Trevor Distin
National Technology Manager
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Greystanes House, 107 Clunies Ross Street, PROSPECT
New South Wales 2148
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Why on tour: Interested in the progress being made in the use of bitumen rubber in seals & asphalt, high modulus asphalt and warm mix asphalt technologies. Other interests are BTB & surface rejuvenation. Also to attend my 6th CAPSA conference.

Background: Over 25 years experience in the bituminous products industry. Previously employed by Mobil, Colas and Sabita in South Africa. Been in my current position for the last 2.5 years.
**John Esnouf**  
Principal Engineer - Sprayed Seal Technology  
VicRoads - Technical Consulting, VicRoads  
57 Lansell Street BENDIGO Victoria 3550  
P: +613 5434 5015 M: +61 418 143 781  
E: john.esnouf@roads.vic.gov.au  

*Why on tour:* Keen to learn and observe spray seals as they are applied in South Africa, including: * selection * design * materials * service life * plant & equipment used.  
Interested in surface preparation of new works prior to application of sprayed seals.  
And, maintenance practices and materials.  

*Background:* Been around pavement construction and maintenance and in particular sprayed bituminous surfacings for most of my 40 years with VicRoads. Currently engaged as a specialist surfacing consultant in VicRoads - Technical Consulting.

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**Peter Evans**  
Deputy Chief Engineer (Pavements, Materials & Geotechnical)  
Engineering & Technology Division  
Queensland Department of Transport and Main Roads  
FL 8, 15 Adelaide Street BRISBANE Queensland 4001  
P: +617 3137 7511 M: +61 437 867 592  
E: peter.a.evans@tmr.qld.gov.au  

*Why on tour:* Particularly interested in use of recycled rubber, and all innovative pavement types.  

*Background:* 30 years experience mainly in rural Queensland constructing and maintaining road infrastructure. 6 years as Regional Director South West Queensland until February 2011 - now heading up Pavements Materials and Geotechnical Directorate of E&T. Life long interest in pavements - Lime Stabilisation Steering Committee convenor, trials of BTB, major trials of rubber modified bitumen in SW Queensland.

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**Jaco Liebenberg**  
Principal Pavement Engineer  
GHD  
201 Charlotte Street BRISBANE Queensland 4000  
P: +617 2216 3186 M: +61 437 867 592  
E: jaco.liebenberg@ghd.com  

*Why on tour:* Presenting two papers at the CAPSA conference.  
Accompany delegates from Australian Road Authorities in South Africa and shares Southern Africa experience and network with them.  

GHD Principal pavement Engineer: 2009 - date.  
PrEng MSAICE CEng MIEI
Russell Lowe
Principal Technologist (Bitumen Surfacing)
Metropolitan Regional, Assets and Operations Division
Queensland Department of Transport and Main Roads
Floor Gr, Nathan Depot, 1 University Avenue
NATHAN Queensland 4111
P: +617 3347 5262 M: +61 418 871 072
E: russell.j.lowe@tmr.qld.gov.au

Why on tour: Learn from South African approaches for bitumen surfacings upon high traffic and low volume roads to minimise maintenance, meet with Sanral&Sabita establish contacts and exchange & share knowledge and experience.

Background: 10yrs Geotechnical Labs NSW&Vic, 6yrs Boral Asphalt Qld Lab & Technical Supervisor, 9 yrs QTMR Herston - R&D projects & AC audits programs, last 6 yrs Metro Region Brisbane Asset Preservation and Maintenance , Assoc Dip Lab Tech

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National Technical Leader
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ARRB Group Ltd
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Why on tour: key interests are all aspects of sprayed sealing, and sealing binders. Also interested in forming a Southern Hemisphere Sprayed Sealing Alliance, based in the interest shown after the 1st and 2nd International Sprayed Sealing Conferences.
17 years sprayed sealing experience with Department of Transport, South Australia, followed by 4 years experience in sprayed sealing research at ARRB Group. Also Chairman of the Standards Australia committee for road-making bitumen.

Rob Vos
Queensland Executive
Australian Asphalt Pavement Association
903c Toowong Tower, 9 Sherwood Road, TOOWONG
Queensland 4066
P: +617 3870 2644 M: +61 414 533 481
E: robert.vos@aapa.asn.au

Why on tour: Learn about the status of the key issues in South Africa. Meet the lead practitioners and share knowledge and contact. Seek details on HAPAS style product implementation.

Background: 13 years at Cape Province Roads, 10 years Technical Director Sabita, last 11 years in AAPA in Queensland. BSc.Eng.Civil, Pr.Eng, C.Eng, MSAICE,MICE
Appendix 9.3 – AAPA 2011 Study Tour Question List

This Questions List (12 August 2011 version 3) for the AAPA 2011 Study Tour & CAPSA’11 includes details of Areas of Interest and questions or issues that have been raised by the delegate. Suggested topics for the Society for Asphalt Technology Workshops in the Cape Town & Johannesburg Areas are detailed.

AREAS OF INTEREST (will also include specific tour member interests)

A: Surface treatments: comparison & cost effectiveness of alternative treatments
1. Sprayed seals – operations, binder selection, quality and materials evaluations, industrial safety
2. Slurry seals – use of micro surfacing for rut filling and overlays, material evaluation and mix design
3. Surface rejuvenation – use of rejuvenators for surface enrichment, selection criteria and application

B: Binders – use of bitumen rubber in sprayed seals and asphalt wearing courses, availability and specification requirements including quality control measure to ensure compliance.

C: Improving pavement performance – modelling, accelerated testing, design methods & models, foam bitumen stabilisation and bitumen treated base experience and transfer of high modulus asphalt technology to RSA.

D: Sustainability – recycling, warm mix asphalt, efforts to reduce carbon footprint, carbon calculators and impacts for road asset management

CAPSA’11 details

Theme: Roads of the future
Focus area 1 – Reduced energy consumption of bitumen layers
Focus area 2 – Reducing the impact of road building activities on the environment
Focus area 3 – Designing for extended performance of bituminous layers
Focus area 4 – Flexible pavement systems for extended life
Focus area 5 – Asset Management

A: Surface Treatments
Sprayed Seals

Q 2. What percentage of the South Africa network is sprayed seals?
Q 3. What are the most common seal types, and aggregate sizes?
Q 4. How commonly used are Cape Seals, has there application been mechanised, what traffic loading can be accommodated?
Q 5. What standard operations are used in sprayed sealing, are bitumen sprayers uniformly calibrated across the country, are bitumen sprayers certified to use in other jurisdictions?
Q 6. Are bitumen rubber & polymer modified binder sprayers different to normal bitumen sprayers – are they calibrated & certified differently?

Q 7. How are road surface types selected, is there a local or national norm, what factors are considered when selecting the given surface? Are there particular treatments used for particular reasons?

Q 8. Is the type of binder to be used included in the selection process or is that determined by the seal design process?

Q 9. What range of road grade and modified binders are used in sprayed sealing and what volumes or percentages are sprayed annually?

Q 10. Are polymer modified emulsions used in sprayed sealing? If yes what are the key motivators and what are the operational and cost implications?

Q 11. Does the public sector participate in sprayed sealing (percentage private to public)?

Q 12. Are binders bought in bulk by the client? If yes how is binder allocated to contracts?

Q 13. Are newer sprayers with different international technologies being used?

Q 14. Has the comparative performance of the various polymer modified binders and rubber bitumen used in seals been reviewed?

Q 15. What has been the experience with the performance of SBS seals with the onset of winter?

Q 16. Are performance or functional specifications used in the purchase of surface seals?

Q 17. Are there best practice procedures for:
   a. surface pre-treatments including rut filling,
   b. surface rejuvenation and crack sealing;
   c. cutting back of binders,
   d. the use of bitumen emulsions;
   e. use of self propelled chip spreaders versus spreader boxes,
   f. calibration of sprayers,
   g. on site blending of bitumen rubber,
   h. pre-coating of aggregates, and
   i. priming of base courses.

Q 18. Are performance or functional specifications used in the purchase of surface seals?

Q 19. What allowances are made in the variations of material qualities to achieve optimal use of scarce natural aggregates? Is this included integrated into the seal design and the performance evaluation?

Q 20. What impacts have industrial occupational health and safety requirements had on sprayed sealing operations and materials selection?

Q 21. What allowance is made in the design spray rate to differentiate between the performance properties of the different binders?

Q 22. What tests and acceptance criteria are use for granular base courses prior to sealing ie % dry back, embedment etc

Q 23. What is the maximum traffic volume and other limiting factors used for spray seals selection ?

Q 24. How do they address seal failures ie bleeding , flushing ,stripping , ravelling etc?
Q 25. How is funding for sealing and maintenance procured? How are sites for sealing selected? What process is used to rank these sites?

Q 26. What percentage of roads is resealed annually? What is the life expectancy of seals in South Africa?

Q 27. To what extent are geotextile seals used? Are there any guidelines for the use of geotextile seals in areas of high stress?

Q 28. What properties are specified for sealing aggregates? Is a minimum average least dimension required?

Q 29. Bitumen rubber seals using high binder application rates have been reported on (Jooste K & van Zyl GD 2010). How are these seals performing? Under what conditions are they used?

**Slurry Seals**

Q 1. What is the primary use of slurry seals? Urban networks? Rural network?

Q 2. Are slurry / micro-surfacings used as rut filling and overlays? Are they used to improve skid resistance? What life expectancy is achieved? What mix design methods are used? Any lessons learnt or best practice guides? Are there performance records?

Q 3. Is the equipment used of a similar type / standardised?

Q 4. Are slurry / micro-surfacings sold under brand names? Are they included in a HAPAS type certification process?

Q 5. Are they using PMB emulsions in their slurry seals if so what kind?

**Surface Rejuvenation**

Q 1. Is surface enrichment a common practice?

Q 2. What is the primary motivation for using surface rejuvenation?

Q 3. Is it included in seal design and application?

Q 4. What selection / performance criteria are used in choosing a surface enrichment product?

Q 5. What application rates are used? What are the costs / area of the products used?

Q 6. What binder types are used for surface enrichment?

Q 7. Are special commercial products / petroleum product formulations used for rejuvenation?

Q 8. Is there a formal design process?

Q 9. What are the life cycle cost benefits of surface rejuvenation?

Q 10. What rejuvenation treatments are used on asphalt surfaced pavements where the environment rather than loading is the major influence on deterioration? (eg low volume residential streets in cities)
B: Binders

Q 24. Does South Africa import bitumen yet? If not, why not?

Q 25. Are penetration or viscosity graded binders used? Has any attempt made to link empirical properties to performance?

Q 26. Are there different specifications for asphalt and sprayed sealing grades of road grade and modified binders?

Q 27. Is any attempt made to compare to international grades of binders (Superpave Performance Grading)?

Q 28. What tests are used to evaluate the binder properties over the operational temperature spectrum especially at low in-service temperatures in seals?

Q 29. Are cut-back binders used, if yes what percentage of the overall binder usage? Are there best performance guides for blending cutback in the field?

Q 30. What elastomeric and plastomeric modifiers are available? Does the specification identify them by type? What relative percentages of the modifiers are used?

Q 31. Is crumb rubber (bitumen rubber) commonly used? In sprayed sealing? In asphalt? What percentage in each application?

Q 32. How is crumb rubber included in sprayed sealing? Direct mixing in bitumen sprayers? Terminal blending and long distance hauling? Field blending at point of application?

Q 33. Does environmental benefit or sustainability enter into consideration in the selection of binders?

Q 34. What efforts are being made to use alternatives to crude oil sourced bituminous binders? Are their binders commercially available?

Q 35. What modified binders are commonly used in asphalt manufacture? Is the selection based on performance? Have long term performance trials been undertaken to assess the advantages?

Q 36. Has accelerated pavement testing (HVS) been used to assess the performance improvements for modified and bitumen rubber for seal and asphalt? If yes, have the results been included in design guides?

Q 37. Do specifications, test procedures and best practice guides exist for crumb rubber binders (bitumen rubber)?

Q 38. What attempts have been made to improve the plastomeric properties of crumb rubber binders?

Q 39. What attempts have been made to lower the handling temperature and improve the self life of crumb rubber binders?

Q 40. What properties are required for rubber crumb?

Q 41. How are modified binder specified? At what point are properties for modified binders applied? Point of manufacture or at the point they are delivered to site?

Q 42. How is segregation and degradation of modified binders controlled? What specification limits are in place?
Q 43. To what extent are emulsions used in sealing? Is there a push to use emulsions based on environmental reasons?

Q 44. What lab test method and limits are used to measure the storage stability and degradation of PMB’s?

Q 45. Are high modulus asphalt technologies available? What lessons have been learnt in the acquisition of the necessary materials and skills to deliver the asphalt? Will the material be subjected to APT and is it likely to be included in the SA Pavement Design Method?

Q 46. Is binder sampled at point of use for quality assessment? If so how, and what tests are undertaken?

C: Improving Pavement Performance

Q 1. What is Godzilla and is it likely to spread into other countries? Feedback on this clearly a big and ambitious project and its links to performance records, wider range of engineering and reference testing and use in full pavement & surfacing performance would be valuable!

Q 2. Is the Fatigue Endurance Limit concept to be included in South African pavement design?

Q 3. Is the “perpetual pavement concept” of value and is the international efforts on this likely to impact on pavement thickness design?

Q 4. What accelerated pavement testing is being undertaken? How is it input into current design models? Are there links to international APT facilities? Are there links to the NCAT test track?

Q 5. Has the investment in APT improved the performance of the South African roads network? Explain if yes.

Q 6. Are high modulus asphalt technologies available? What lessons have been learnt in the acquisition of the necessary materials and skills to deliver the asphalt? Will the material be subjected to APT and is it likely to be included in the SA Pavement Design Method?

Q 7. How have you managed to calibrate local test methods with the French EME mix design methods? Have you established equivalent test values for fatigue and wheel tracking performance?

Q 8. What parameters have you used to obtain the required properties for EME bitumen ie Penetration Index etc

Q 9. What is the local experience with regards to early life skid resistance and permeability of SMA? Do you apply grit and how do you prevent ingress of water into the pavement? What are your permeability and texture requirements?

Q 10. What are your mix design and field compaction requirements for BTB?

Q 11. How are high performance thin asphalt surfacing specified and tested for compliance? Has the Agreement system been implemented and how has it been accepted by the Industry?

Q 12. What key pavement evaluation tests for network level evaluation? Is Ground Penetrating Radar being used? Are standard network level tests undertaken across the South African network or are the results assessed differently in each of the Provinces? Are there differences between the approaches used for urban networks vs non-urban?

Q 13. What methods are used to avoid/delay reflection of underlying asphalt cracking when resurfacing/overlay with asphalt? What results are achieved?
Appendix 9.3- Question List

Q 14. Is pavement maintenance funded nationally? And if so, what basis is used nor allocation of pavement repair funding in non-national jurisdictions? Does this have an impact on the overall level of service of the roads?

Q 15. Does the economic development value of road infrastructure enter into the provision of roads and the pavement types / structures selected?

Q 16. What relative amounts of foam and emulsion stabilised base courses are used? Are there performance & design models available? What development work is being undertaken? Are there clearly different applications for emulsion vs foam stabilisation?

Q 17. What new concepts and pavement performance options are under research?

Q 18. What sustainability and CO₂ reduction drivers exist in the roads sector and how are they being evaluated and addressed against pavement performance? Are trade-offs permitted for reduced performance but improved sustainability? (use of lower standard materials, recycled waste materials etc)

Q 19. Do they consider maintenance minimisation in the road design especially in the design and construct type contracts?

Q 20. How do they approve asphalt mix designs and what is their process of validation?

Q 21. What is the South African approach to managing skid resistance?

D: Sustainability

Q 1. What percentages of recycled asphalt is used in South Africa? Estimated tonnage? Does it vary by urban / regional and by Province.

Q 2. What percentages of RAP are allowed in wearing course, binder course, base course?

Q 3. Are their restrictions on the use of modified binders in RAP? Are their restrictions on the use of RAP in modified binder mixes?

Q 4. What sustainability and CO₂ reduction drivers exist in the roads sector?

Q 5. Are recycled waste materials (glass, concrete, brick, sulphur etc ) permitted for use in asphalt? If yes, what proportions and what applications?

Q 6. Are carbon footprint and CO₂eqi Calculators being used? If yes, which ones?

Q 7. Are there CO₂eqi reduction initiatives in the purchase of bituminous surfacings or asphalt pavements?

Q 8. Do road asset management policies include carbon reduction? What initiatives are in place to reduce any impact?

Q 9. Is warm mix asphalt and low energy asphalt being routinely used? What implementation strategy was used to introduce and evaluate the WMA performance?

Q 10. What warm mix asphalt technologies are in regular use?

Q 11. What compaction criteria are used for testing warm mix asphalt samples to check compliance for air voids?

Q 12. What changes have been made to hot mix asphalt specifications to accommodate warm mix asphalt?
Q 13. How do they manage RAP from milling of the City & Urban projects is Sanral or Sabita responsible for transport, storage and processing of RAP?

Q 14. SMA has longer life than DGA & OGA and less carbon footprint where are they up to with SMA selection and design and specification development and use?

Q 15. Are recycled or waste materials being used for sealing aggregates

E: General

General Questions

From Derek Millar – QTMR

- (Question for Lou) recall back in my SANRAL days that the texture depths for SMA surfacings typically dropped significantly after year 5 (SANRAL use to measure annually / bi-annually their network texture depths etc). I would be interested to ascertain if the texture depths had got any worse or if loss of texture tapered off. Usually we would expect 1.2 - 1.5 mm texture depth at construction which was much better than 0.7 for the DG mixes so perhaps not an issues when starting off much higher?

- Also, on my last project it was more cost effective to use a 20mm UTFC layer on a 35mm DG14 type mix than a 50mm SMA. So it made sense to use this approach rather than the SMA. I would like to know if SANRAL is still using SMA or has it's use dropped off since the introduction of UTFC type surfacings? I still like the idea of a composite asphalt layer and believe that like the French we should be using a UTFC surfacing seal that is replaced every 6-8 years on our higher level roads here in QLD. On rural roads we should use double seals.

- (Question for Dennis Rossman) I understand that SANRAL are looking at G1 bases with 1% emulsion. I have wondered for a long time whether there is any benefit in this and proposed it years ago. Has SANRAL started any trials with this and if so what are the results like thus far?

- (Question for Low) Because SANRAL have such a good network measurement system in place they also put allot of emphasis in asset preservation projects (these normally get first priority when allocating their annual budget with capex expenditure secondary ) it would be interesting to see the volumes of surfacing undertaken i.e. seals (type - single. double, rubber bitumen), asphalt surfacings (UTFC, SMA, DG) and concrete?

- Between 2000 and 2007 when I left, SANRAL applied allot of double seals (strictly 1.5 seals) over their rural and sometimes urban freeways; how have these fared now that they have had 5 years and more traffic? I think the design life was 6-8 years. They were mostly modified seals some where bitumen rubber.

- (Question for Dennis Rossman) As far as I am aware SANRAL have only used foam bitumen bases on low risk roads (i.e R22 - be interesting to know how the R22 has performed?); has the use of foam bitumen bases increased or is the G1 base still the preferred base option? This would also apply for subbase layers where SANRAL in the past mostly use lime, slag or cement stabilised subbases?

- (Question for Dennis Rossman) There were a few SANRAL projects that used a concrete inlay with an asphalt surfacing in truck lanes (N2 just south of Durban), how have these performed to date and is it an option that SANRAL will continue to use?
From Jaco

- How does SANRAL identify resurfacing, rehabilitation and upgrading projects on their network and assign priorities. What is the life cycle of a project from identification to completion of construction?
### Appendix 9.4 – South African Acronyms, Abbreviations, & Quotes

#### South African Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAAAAA</td>
<td>African-Australian association against acronym abuse</td>
</tr>
<tr>
<td>A-E1</td>
<td>Asphalt binder, elastomeric, low polymer (SBS &amp; SBR)</td>
</tr>
<tr>
<td>A-E2</td>
<td>Asphalt binder, elastomeric, medium polymer (mostly SBS)</td>
</tr>
<tr>
<td>A-H1</td>
<td>Asphalt binder, hydrocarbon, 4-5% Gilsonite</td>
</tr>
<tr>
<td>A-H2</td>
<td>Asphalt binder, hydrocarbon, 3-4% Sasobit</td>
</tr>
<tr>
<td>APT</td>
<td>Accelerated pavement testing</td>
</tr>
<tr>
<td>AsAc</td>
<td>Asphalt Academy</td>
</tr>
<tr>
<td>ASC</td>
<td>Australian sand circle test</td>
</tr>
<tr>
<td>BR</td>
<td>Bitumen rubber</td>
</tr>
<tr>
<td>BRA</td>
<td>Bitumen rubber asphalt (dense grade – see SABITA manual 19)</td>
</tr>
<tr>
<td>BRASO</td>
<td>Bitumen rubber asphalt open grade</td>
</tr>
<tr>
<td>BTB</td>
<td>Bitumen treated base course</td>
</tr>
<tr>
<td>C4</td>
<td>A cement stabilised material</td>
</tr>
<tr>
<td>CAPSA</td>
<td>Conference on asphalt pavements for Southern Africa</td>
</tr>
<tr>
<td>CMP</td>
<td>Construction management program (1 wk. course at Stellenbosch Uni.)</td>
</tr>
<tr>
<td>COLTO</td>
<td>Committee Of Land Transportation Officials (authors specifications which are posted on SANRAL web site)</td>
</tr>
<tr>
<td>COP17</td>
<td>17th conference of the parties (environmental)</td>
</tr>
<tr>
<td>CPX</td>
<td>Close proximity (method of noise measurement)</td>
</tr>
<tr>
<td>CSIR</td>
<td>Council for Scientific and Industrial Research</td>
</tr>
<tr>
<td>CTM</td>
<td>Circular track meter (gives MPD)</td>
</tr>
<tr>
<td>DE</td>
<td>Diluted emulsion</td>
</tr>
<tr>
<td>Acronym</td>
<td>Means</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>DORA</td>
<td>Determination of revenue allocation (heard at SANRAL)</td>
</tr>
<tr>
<td>DRC</td>
<td>Democratic republic of Congo</td>
</tr>
<tr>
<td>DSR</td>
<td>Dynamic shear rheometer</td>
</tr>
<tr>
<td>Elv</td>
<td>Equivalent light vehicle</td>
</tr>
<tr>
<td>EME</td>
<td>Enrobé à Module Elevé</td>
</tr>
<tr>
<td>F-T wax</td>
<td>A paraffin wax developed by German chemist Frans Fischer and his Czech colleague Hans Tropsch in 1922.</td>
</tr>
<tr>
<td>GIS</td>
<td>Geospatial information system</td>
</tr>
<tr>
<td>HiMA</td>
<td>High modulus asphalt, equivalent to EME</td>
</tr>
<tr>
<td>HiPAT</td>
<td>An adapted Pressure Aging Vessel test (Johan Muller)</td>
</tr>
<tr>
<td>HFO</td>
<td>Heavy fuel oil</td>
</tr>
<tr>
<td>HVS</td>
<td>Heavy vehicle simulator</td>
</tr>
<tr>
<td>IBEF</td>
<td>International bitumen emulsion federation</td>
</tr>
<tr>
<td>ICAO</td>
<td>International civil aviation organisation</td>
</tr>
<tr>
<td>$J_{nr}$</td>
<td>The average non-recoverable creep compliance from the DSR MSCR test</td>
</tr>
<tr>
<td>KMA</td>
<td>A Wirtgen cold mix recycling plant used at eThekwini Municipality</td>
</tr>
<tr>
<td>LAMBS</td>
<td>Large aggregate mixes for bases (see SABITA manual 24)</td>
</tr>
<tr>
<td>MC3000</td>
<td>Pen grade bitumen supplied pre-cut - about 12% cutter (refer SANS 308 or MC 10)</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium development goals (from world bank?)</td>
</tr>
<tr>
<td>MFMA</td>
<td>Municipal finance management act</td>
</tr>
<tr>
<td>MLS</td>
<td>Mobile load simulator</td>
</tr>
<tr>
<td>MMLS3</td>
<td>Model mobile load simulator (1/3rd scale)</td>
</tr>
<tr>
<td>MPD</td>
<td>Mean profile depth</td>
</tr>
<tr>
<td><strong>Acronym</strong></td>
<td><strong>Means</strong></td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td>MSCR</td>
<td>Multiple stress creep and recovery test according to ASTM D7405-08a.</td>
</tr>
<tr>
<td>MSP</td>
<td>Medium set prime</td>
</tr>
<tr>
<td>OBSI</td>
<td>On-board sound intensity</td>
</tr>
<tr>
<td>p</td>
<td>Voids factor (in WCP material manual)</td>
</tr>
<tr>
<td>P&amp;GE</td>
<td>Pavement and geotechnical engineering (eThekwini Municipality)</td>
</tr>
<tr>
<td>PAV</td>
<td>Pressure aging vessel</td>
</tr>
<tr>
<td>PEM</td>
<td>Porous European mix</td>
</tr>
<tr>
<td>PFC</td>
<td>Permeable friction course</td>
</tr>
<tr>
<td>PSV</td>
<td>Polished stone value</td>
</tr>
<tr>
<td>PWOC</td>
<td>Present worth of cost</td>
</tr>
<tr>
<td>RA</td>
<td>Recycled asphalt</td>
</tr>
<tr>
<td>RISFSA</td>
<td>Road infrastructure strategic framework, South Africa</td>
</tr>
<tr>
<td>RNI</td>
<td>Reseal need index</td>
</tr>
<tr>
<td>RSA</td>
<td>Republic of South Africa</td>
</tr>
<tr>
<td>RSM</td>
<td>Road and Stormwater Maintenance (eThekwini Municipality)</td>
</tr>
<tr>
<td>RTFOT</td>
<td>Rolling thin film oven treatment (note this is a treatment, not a test!)</td>
</tr>
<tr>
<td>RUC</td>
<td>Road user costs</td>
</tr>
<tr>
<td>SANS 307</td>
<td>South African national standard specification for penetration grade bitumen</td>
</tr>
<tr>
<td>SANRAL</td>
<td>South African National Roads Agency Limited</td>
</tr>
<tr>
<td>SARF</td>
<td>South African road federation</td>
</tr>
<tr>
<td>SAT</td>
<td>Society of Asphalt Technologists</td>
</tr>
<tr>
<td>S-E1</td>
<td>Sprayed seal binder, elastomeric, low polymer (SBR, SBS)</td>
</tr>
<tr>
<td>S-E2</td>
<td>Sprayed seal binder, elastomeric, medium polymer (~3%)</td>
</tr>
<tr>
<td>SGC</td>
<td>Superpave gyratory compactor</td>
</tr>
<tr>
<td>S-R1</td>
<td>Sprayed seal binder, crumb rubber</td>
</tr>
<tr>
<td>Acronym</td>
<td>Means</td>
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<tr>
<td>---------</td>
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</tr>
<tr>
<td>SRTT</td>
<td>Standard reference test tyre (a Michelin)</td>
</tr>
<tr>
<td>SSA</td>
<td>Sub-Sahara Africa</td>
</tr>
<tr>
<td>STA</td>
<td>Short term aged in the laboratory</td>
</tr>
<tr>
<td>$T^2$</td>
<td>Technology Transfer</td>
</tr>
<tr>
<td>TCE</td>
<td>Tri-chloro-etheleyne (a solvent)</td>
</tr>
<tr>
<td>TNM</td>
<td>Traffic noise model</td>
</tr>
<tr>
<td>TSRST</td>
<td>Tensile test restrained specimen test</td>
</tr>
<tr>
<td>UKZN</td>
<td>University of Kwa Zulu Natal</td>
</tr>
<tr>
<td>VOC</td>
<td>Vehicle operating costs</td>
</tr>
<tr>
<td>VTS</td>
<td>Viscosity-Temperature Susceptibility - empirical value that gives a measure of temperature sensitivity, larger value = greater susceptibility</td>
</tr>
<tr>
<td>WCP</td>
<td>Western Cape Province</td>
</tr>
<tr>
<td>WMA-T</td>
<td>Warm mix asphalt technologies</td>
</tr>
</tbody>
</table>

**Glossary**

<table>
<thead>
<tr>
<th>South Africa</th>
<th>Australia</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen rubber</td>
<td>Crumb rubber</td>
<td></td>
</tr>
<tr>
<td>Circle</td>
<td>roundabout</td>
<td></td>
</tr>
<tr>
<td>Conversion factor</td>
<td>Polymer factor</td>
<td>Used in PMB design</td>
</tr>
<tr>
<td>Heavy fuel oil</td>
<td>Diesel</td>
<td></td>
</tr>
<tr>
<td>Paraffin</td>
<td>Kerosene</td>
<td>cutter</td>
</tr>
<tr>
<td>Recycled Asphalt</td>
<td>Reclaimed Asphalt Planings</td>
<td>RAP</td>
</tr>
<tr>
<td>Robot</td>
<td>Traffic light</td>
<td></td>
</tr>
<tr>
<td>Rolling stones test</td>
<td></td>
<td>A stripping test <em>(for groupies?)</em></td>
</tr>
</tbody>
</table>
Quotations

At low temperatures, it’s as brittle as a biscuit – Kobus Louw

In your parallel alternative reality..... – Robyn the tour guide

The master of the universe – Robyn, referring to Rob Vos

Crystal balls are a wonderful thing – they reflect the person who is looking in – Rob Vos

We do measure skid but we don’t tell the people

It’s like a circus, just the animals are different – comment on bitumen supply in South Africa

Eish!! – an expression of surprise

We try to manualise things

Even a stiff thing needs support

Q. What is the life expectancy of sprayed seals in South Africa?
A. Another year.

....he is valuable as a thinking machine.

It is very easy to focus on asset management when your funding is not competing with bus services and corruption and that sort of thing.

Perpetual? A hell of a long time!
Appendix 9.5 - References

In the electronic version of this report the references are included and can be accessed below.

Pretour

1. Louw Kannemeyer, Godzilla Basics 2007

Tour member presentations

1. Distin, Sprayed seals – contractors experience
2. Esnouf, Can we use sprayed seals in high stress areas
3. Esnouf, Victoria Floods 2011
4. Liebenberg, Australian Pavement Design
5. Lowe, SMA and water
6. Neaylon, SHSSA CAPSA’11
7. Vos, Bitumen Imports
8. Vos, Opening introduction to the AAPA 2011 Study Tour

Cape Town / Stellenbosch

1. Gerber, Seal modeling and design – SAPDM, presentation September 2011
2. Jenkins, BSM Recycling Technology Update, presentation September 2011
3. Jenkins, HiMA and EME, presentation September 2011
4. Jenkins, Warm Mix Asphalt, presentation September 2011
5. Jenkins, SANRAL Chair PG research activities, presentation September 2011
6. van der Walt, SANRAL presentation, September 2011
7. van Zyl & Louw, Sprayed Seals, presentation September 2011
## Johannesburg / Pretoria

1. Denneman, Agrement proceses, presentation September 2011
2. Denneman, HiMA, presentation September 2011
3. Denneman, SAT 2007 application of locally developed pavement temperature prediction algorithms, presentation September 2011
4. Kannemeyer, SANRAL asset management overview, presentation September 2011
5. O’Connell, Questions List & State binders research in RSA, presentation September 2011
6. Verhaeghe, Overview of CSIR activities, presentation September 2011
7. Judd, Heavy volume surfacing seals, presentation from CAPSA’07

## Durban

1. Gooden, Procurement Infrastructure, presentation September 2011
2. Lathiieef, eThekwini PMS, presentation September 2011
3. Lewis, Discussion with Aussie delegation – WMA, presentation September 2011
4. Naidoo, Sustainability in eThekwini, presentation September 2011
5. Nortje, HiMA trial report, Australian Tour, presentation September 2011

## KNP

1. Louw, KNP Stabilised section trials
2. Louw et al, Performance of sand seals in the KNP

## Post Tour

1. CAPSA’04 Rut filling
2. CAPSA’04 Slurry edge wdiening
3. CAPSA’04 Surface rejuvenation
### SABITA Reference Material

1. Manual 5 - Guidelines for the manufacture and construction of hot mix asphalt
3. Manual 8 - Guidelines for the safe and responsible use of bituminous products
5. Manual 17 - The design and use of porous asphalt mixes
6. Manual 19 - Guidelines for the design, manufacture and construction of bitumen rubber asphalt wearing courses
7. Manual 22 - Hot mix paving in adverse weather
9. Manual 24 - User guide for the design of hot mix asphalt
10. Manual 25 - Quality management in the handling and transport of bituminous binders
11. Manual 26 - Interim guidelines for primes and stone precoating fluids
12. Manual 27 - Guideline for thin layer hot mix asphalt wearing courses on residential streets
13. Manual 28 - Best practice for the design and construction of slurry seals
15. Manual 31 - Guidelines for calibrating a binder distributor and ensuring satisfactory performance
16. Sabita Information Sheet #10 – Asphalt and society
17. Implication of the Proposed Carbon Tax Legislative and Policy Framework on SABITA Members

### Asphalt Academy Reference Material

1. Technical Guide 1 - The use of modified bituminous binders in road construction
2. Technical Guide 2 - A guideline for the design and construction of bitumen emulsion and foamed bitumen stabilised materials
3. Technical Guide 3 - Asphalt reinforcement guide
**CAPSA’11**

**FOCUS AREA 1:**
Reduced energy consumption in the construction of bituminous layers

Document Links
- Combining ICC and energy consumption for enhancing decision making regarding rehabilitation options (Kim Jenkins)
- Low energy asphalt mixtures for sustainable and durable pavement solutions (Martin van de Ven)
- Design of recycled asphalt mixtures using a double drum mixer (Andre Molenaar)
- Warm mix asphalt - the South African experience (Krishna Naidoo)
- Low emission & low energy asphalts for sustainable road construction: the European experience of LEA process (Francois Olard)

**FOCUS AREA 2:**
Reducing the impact of road building activities on the environment

Document Links
- Asphalt mixtures with waste materials: possibilities and constraints (Martin van de Ven)
- The performance of environmentally beneficial asphalt products: practical case studies at OR Tambo International Airport over the last 5 years (Jannie Grobler)
- Towards more sustainable practice in bituminous products laboratories (Johan O’Connell)
- Evaluation of the OBSI method (Andre Smit)
- Bitumen emulsions: beyond pavement preservation (Etienne M. le Bouteiller)
- Application of innovations and lessons learnt on a sinkhole prone runway reconstruction (Bruce Morton)
- Construction of a high quality asphalt wearing course with more than 90% reclaimed asphalt pavement (RA); a case study (Matthias Nötting)
- Steel Slag. Conversion of an industrial waste material into a value adding asphalt ingredient (Gunnar Winkelmann)
## Appendix 9.5 – References

### FOCUS AREA 3: Designing for extended performance of asphalt

| Document Links                                                                 |
|                                                                               |
| Roughness as an important parameter in adhesion considerations (Martin van de Ven) |
| Impacts of cement content on properties of foamed asphalt cold recycling mixtures (Jian Xu) |
| Development of a test method for determining emulsion bond strength using the bitumen bond strength (BBS) test - a South African perspective (Andre Greyling) |
| Improving the durability of seal aggregate by pre-coating (Tumelo Thothela) |
| Development of optimal runway friction systems for Southern African international airports (Jannie Grobler) |
| Cracking and staining of an airport asphalt (Frank Netterberg) |
| Improving runway skid resistance at King Shaka International airport through ultra-high pressure water-cutting (Wim Hofsink) |
| Effect of sample geometry on bulk relative density of hot-mix asphalt mixes (Joseph Anochie-Bcateng) |
| Innovations on the asphalt mix design for the rehabilitation of National route 3 between Mariannhill and Key Ridge (Jaco Liebenberg) |
| 8 years of foamed bitumen stabilisation in New Zealand - a performance review and comparison to overseas (Allon Brown) |
| Development of performance criteria for cold-lay surfacing materials: laboratory study (Erik Denneman) |
| Addressing durability and stripping issues in asphalt bases and surfacings (Emile Horak) |
| Novel measures to attenuate aggressive salt migration and crystallization on a Namibian airport runway project (Emile Horak) |
| The use of rigid voids and variations of the ring and ball test to determine the effect of filler sized material in sand emulsion mixes (Emile Horak) |
| The influence of temperature distribution and voids characteristics on durability behaviour of bitumen stabilized materials (EM Twagira) |
| The development & implementation of cost effective coloured bituminous surfacings for high performance bus lanes: case study on Cape Town and other IRT Projects (Ian Bowker) |
| Seal performance based on pavement management system data (Gerhardt Van Zyl) |
| Establishment of appropriate slurry seal design methods for South Africa (Gerhardt Van Zyl) |
| The development and performance of a new ultra thin friction course for OR Tambo International airport in South Africa (Pieter Molenaar) |
| Critical review of performance of UTFC in South Africa (Corne Roux) |
| Evaluation of performance of asphalt paving mixes under harsh conditions using the MMLS3 (Frederick Hugo) |
| Gb8: innovative design of high-performance asphalt mixes for long-life & cost-effective pavements by optimizing aggregates & using SBS modified bitumen (F Olard) |
| Sealing in adverse weather (M Bouwmeester) |
### Appendix 9.5 – References

#### FOCUS AREA 4: Flexible pavement systems for extended life

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<thead>
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<th>Document Links</th>
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<tr>
<td>Transfer of high modulus asphalt technology to South Africa (Erik Dennenman)</td>
</tr>
<tr>
<td>Evaluation of resilient modulus models for G1 granular material (Jingang Wang)</td>
</tr>
<tr>
<td>Pavement strength balance and its practical implications (Eduard Klayn)</td>
</tr>
<tr>
<td>Development of a pavement performance information system (PPIS) (Arno Hefer)</td>
</tr>
<tr>
<td>Interim revision of the South African mechanistic-empirical pavement design method for flexible pavements (Hechter Theys)</td>
</tr>
<tr>
<td>Prediction of the mechanical characteristics of cement treated demolition waste for road bases and sub-bases (Andre Molenaar)</td>
</tr>
<tr>
<td>Repeated load CBR testing a simple but effective tool for characterising soils and unbound granular materials (Andre Molenaar)</td>
</tr>
<tr>
<td>Revision of damage models for asphalt pavement (Erik Dennenman)</td>
</tr>
<tr>
<td>Application of visco-elastic models to flexible pavement analysis (James Maina)</td>
</tr>
<tr>
<td>Resilient response characterisation of hot-mix asphalt mixes for a new South African pavement design method (Joseph Anochie-Bozeng)</td>
</tr>
<tr>
<td>The long-term behaviour of bitumen stabilised materials (BSM3) (Dave Collings)</td>
</tr>
<tr>
<td>Behaviour of an emulsion treated base (ETB) layer as determined from heavy vehicles simulator (HVS) testing (Gerrit Jordaan)</td>
</tr>
<tr>
<td>Modeling the non-linear behaviour of pavement layers (subgrade) using a linear elastic approach (PW de Bruin)</td>
</tr>
<tr>
<td>Practical guidelines used to assist with the accurate characterisation and modeling of pavement materials and layers in the SAMDM (PW de Bruin)</td>
</tr>
<tr>
<td>Flexural stiffness and fatigue properties of warm mix asphalt (Alex Mbaraga)</td>
</tr>
</tbody>
</table>

#### FOCUS AREA 5: Meeting the needs of society

<table>
<thead>
<tr>
<th>Document Links</th>
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</thead>
<tbody>
<tr>
<td>Tendering for professional services: both sides of the coin (Jaco Liebenberg)</td>
</tr>
<tr>
<td>Overview of a pavement management system in a toll road context (Douglas Juckl)</td>
</tr>
<tr>
<td>Knowledge management maturity assessment in the roads engineering environment (Innocent Jumo)</td>
</tr>
<tr>
<td>Recommendations regarding higher axle mass limits for axles fitted with wide base tyres (Michael Roux)</td>
</tr>
<tr>
<td>The effect of law enforcement and tolling of national roads on the South African rural road network - a case study (Gerrit Jordaan)</td>
</tr>
<tr>
<td>Life cycle cost analyses - an integral part of pavement rehabilitation design (Gerrit Jordaan)</td>
</tr>
<tr>
<td>Road management data assimilation and quality control of asphalt and bituminous pavements using GPR (Terence Ian Milne)</td>
</tr>
</tbody>
</table>
**FOCUS AREA 6:**
Speciality Area Bituminous Binders

Document Links

- Adjusting the standard rolling thin film oven procedure to improve the prediction of short term ageing (Johan O’Connell)
- The use of the dynamic shear rheometer (DSR) to predict the penetration of bitumen (Jacques van Heerden)
- The use of an extended rolling thin film ageing method as an alternative to pressurised ageing vessel in the determination of bitumen durability (Johan Muller)
- Effect of shear rate on bitumen viscosity measurements - relevance to high temperature processing of bituminous (Georges Mturi)

**BULLETIN PAPERS:**

Document Links

- Energy and related carbon emission reduction technologies for hot mix asphalt plants (Oliver Stotko)
- Effectiveness of calibrated HDM-4 models for predicting the condition of surfaced roads over the long term (Mervyn G Henderson)
- Investigation on Asphalt roads within the Port of Durban (Oscar Kunene)
- Improving the Productivity and Performance of Queensland’s Roads (Mervyn G Henderson)
- Towards improved understanding of seal performance (GD van Zyl)
- Full-scale implementation of warm mix asphalt in South Africa (Wynand Nortje)
AAPA is a representative industry association for the flexible pavement sector. It was formed in 1969 as a non-profit organisation to promote the economic use of asphalt and bitumen bound products based on sound technical and commercial grounds.