Quality of South African bitumen measured against international performance based specifications

The bitumen from all four South African refineries complies with specific grades of the Superpave classification system. This emerged from the full range of Superpave tests carried out University of Wisconsin, Madison (except the extremely low temperature tests as these were not deemed applicable to local in-service conditions).

The tests, conducted by Prof Kim Jenkins, SANRAL Chair of Pavement Engineering at the University of Stellenbosch, in collaboration with Prof Hussain Bahia, of the University of Wisconsin, were motivated by the intent, expressed by the Road Pavement Forum (RPF), to develop a performance based classification system for bitumen specification in South Africa. The tests used samples of penetration grade bitumens from our local refineries, sent to the United States for finger printing against the Superpave binder specifications, and included Dynamic Shear Rheometer (DSR) and Bending Beam Rheometer (BBR) tests on unaged bitumen, as well as bitumen aged according to the Rolling Thin Film Oven Test (RTFOT) and Pressure Ageing Vessel (PAV) methods.

Superpave grading system

Performance grade binder specifications were implemented in the USA in 1995 as a result of a $150 million research programme to improve the performance of asphalt roads against deformation, cracking and durability. The purpose of what has become known as Superpave (Super Performing Asphalt Pavements) is to link the specifications with the binder performance properties across the entire temperature spectrum. While South African specifications classify the different grades of bitumen based on consistency tests such as penetration at a standard temperature, this classification does not give any indication of the bitumen performance at other temperatures.

The Superpave grading system classifies the binder according to the maximum and minimum pavement temperature range in which it can reasonably be expected to perform. The key difference between local specifications and the Superpave system is that the
physical properties remain constant for all the performance grades, but the temperatures at which these properties must be achieved vary according to the climate in which the binder is expected to be used. For example a PG 58-22 grade binder is designed to sustain the environmental conditions where the average seven day maximum pavement temperature is 52 °C and the minimum pavement design temperature is -22 °C.

**Outcome of Superpave analysis**

The tests carried out on the samples of penetration grade from our four local refineries and the concomitant gradings measured are shown in the table below, bearing in mind that the Superpave system caters for binders to be used in hot mix asphalt only.

<table>
<thead>
<tr>
<th>Compliance of South African bitumen as per Superpave</th>
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<tbody>
<tr>
<td>40/50</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>X</td>
</tr>
<tr>
<td>PG64-16</td>
</tr>
<tr>
<td>PG64-16</td>
</tr>
<tr>
<td>PG70-22</td>
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</tbody>
</table>

From the table we can deduce that at least three grades of bitumen, i.e. 40/50, 60/70 and 80/100 should provide adequate performance in the temperature ranges encountered in South Africa. In other words 80/100 penetration bitumen from local refineries should also render adequate service. Clearly, the RPF task team on bitumen specifications will need to establish suitable temperature ranges which correspond to local climatic conditions. Along with appropriate performance based tests, this would form the basis of a performance classification system.

The performance based test that requires most attention is one which simulates long term ageing of the bitumen in service. While it is desirable to have a specification that is both binder-blind (in terms of modified and unmodified binders) and applicable for use in surfacing seals, we can accept that this development will not be realised in the short term. The task team will, however, continue its work to develop a performance based grading system for SA produced bitumen to suit local climatic conditions.

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**New members further extend Sabita's representation base**

**PD Naidoo & Associates (PDNA)**, with 75% black-ownership and one of South Africa’s largest multi-disciplinary consultancies in the built environment, further extends the growing base of Sabita’s consultant member sector.

Headquartered in Johannesburg, the company serves as a community organisation advising on technical issues in black townships, and its engineering expertise ranges across the spectrum from civil, structural, electrical and mechanical engineering to transportation, traffic and roads systems, water and management services, and mining and industrial consultancy.

The company’s Roads Division has grown significantly since 2003, and a wealth of experience is now available to handle any roads-related project. Investment in a core group specialising in the upgrading, rehabilitation, maintenance and management of roads and road networks has established the company’s leadership role in this field.

Operating as one of South Africa’s top ten engineering consultancies, PDNA boasts a multinational staffing, of which 65% are black. Turnover from its two major operating divisions — consultancy and mining/industrial — exceeded R150-million in 2005. Growth rates year-on-year of more than 40% in the past 12 years have secured a market share of 0.5% of South Africa’s R5-billion consultancy industry.

Gerrie van Zyl will be representing PDNA in its interactions with Sabita.

**Nyanga Roads**, is a Durban-based company specialising in the manufacture and application of bitumen emulsions, primes and hot bitumen, as well as the construction of surface treatments. The company operates numerous binder sprayers, slurry machines, surfacing and patching teams.

Nyanga Roads was established in 1998 and has recently been taken over by Sanyati Holdings (Pty) Ltd., a company listed on the Johannesburg Stock Exchange. Other companies in Sanyati Holdings include Brisk Asphalt and Afriscan Construction. All interests relating to roads activities are under the management of Raymond Deacon.
The production capacity of the four crude oil refineries in South Africa far exceeds the local demand for bitumen.

Addressing industry concerns about bitumen availability at a recent Road Pavements Forum meeting in Durban, Basil Jonsson of Total SA gave an overview of the supply situation facing the bitumen producers in southern Africa, and of the challenges facing the industry in meeting future demand given the anticipated growth in road infrastructure investment.

“While 100% of the crude oil refined in South Africa is imported, bitumen is locally manufactured from the residue of this crude oil. Crude oil is primarily imported to produce fuel of which approximately 75% is refined into white fuels i.e. petrol, diesel and jet A1. The residue not used for bitumen manufacture is further processed into bunker fuel oil for ships. The portion of crude oil that is manufactured into bitumen varies from 1 – 5 % depending on the demand in the product mix for each refinery. The production capacity of the four crude oil refineries far exceeds the local demand for bitumen, so South Africa has emerged as a net exporter of bitumen into the African subcontinent and Indian Ocean Islands. South Africa consumes roughly only 0.25% of the world’s bitumen.”

He added, however, that there were factors which would impact on future supplies of bitumen from local refineries. These are:

- Environmental compliance in providing cleaner fuels;
- Growth in the demand for fuels vis-à-vis bitumen;
- Limitations in current bitumen tankage and loading capacity at the refineries;
- Ageing work force and diminishing skills at the refineries;
- Customer’s requirements with regards to bitumen quality and performance.

“Notwithstanding the above factors, South Africa has the manufacturing capacity to exceed the local demand for bitumen into the foreseeable future, and there is no reason to believe this situation will change,” Jonsson concluded.

SAT recently hosted two well attended seminars in Pretoria and Durban on alternatives to coal tar binders, and another is planned for Cape Town on 7 September.

The main focus of the seminars is to investigate substitute techniques and replacement products to ensure that the inevitable phasing out of coal tar usage in road construction, in line with global best practice, does not leave in its wake a vacuum in terms of appropriate products and processes.

Thus the main aim of the seminars was to mobilise expertise within the SAT membership to define the current domain of the use of coal tar, and to suggest alternative techniques and products. While it was evident that no simple solution for replacing coal tar binders existed for all applications, alternative, cost-effective products and techniques were available.

Although bituminous binders such as MC 30 and inverted bitumen emulsion were available, coal tar exhibited preferred properties such as rapidity of drying, which minimised delays in the surfacing of the base. Problems have been experienced in the slow drying of C 30, especially on G1 crushed stone bases — a problem further exacerbated in colder weather, but alleviated by further cutting back with illuminating kerosene. Another problem was that non-tar products generally did not penetrate moist layers as efficiently.

Tar precoating fluids were preferred over bituminous products because they provided a quicker drying, non- stick coating with a blacker appearance. Despite recent advancements in the development of bituminous based precoating fluids, however, the need to precoat should also be questioned and not just done for the sake of it.

The use of diluted emulsion as a cover spray was found to be very effective for preventing whip off in the early life of a seal.

Given the many variables in selecting the best alternative product or technique, it was decided that the presenters produce an interim ‘best practice’ guideline on priming and precoating at the conclusion of the Cape Town seminar. SAT should be commended for identifying this problem and for playing a vital role in its solution.
HMA innovations sought to improve deformation resistance

In response to Gauteng Department of Public Transport, Roads and Works (GPTRW) concerns about the durability of hot mix asphalt (HMA) wearing courses, Sabita recently mobilised and coordinated expertise within its membership to counter negative perceptions about the ability of HMA to yield adequate performance.

Innovative designs proposed by Sabita members, aimed at meeting GPTRW expectations of reduced rutting and improved resistance to permanent deformation in a range of applications, were tabled at a meeting of the GPTRW Industry Advisory Group (IAG) on hot mix asphalt on 25 July.

The terms of reference of the IAG were established at a meeting in March this year, as reported at the last Road Pavements Forum held in Durban in May.

Negative perceptions

The Sabita initiative was in response to negative perceptions of the performance of HMA wearing courses, based on a wide range of causative factors – some less plausible than others – that could have an adverse influence on the use of this key road building material.

These concerns, in addition to the GPTRW experience of unsatisfactory resistance to permanent deformation of HMA wearing courses at busy intersections (as reported in a forensic study carried out by the CSIR) were compelling reasons for Sabita to take up the challenge.

“Our goal was to ensure that technology related to HMA as a wearing course was sound and up-to-date, and that the product was perceived to be cost-effective,” Sabita CEO Piet Myburgh said.

It was resolved that trial sections be subjected to HVS testing, during which another crucially important issue would be investigated – i.e. the lack of correspondence of approved job-mixes and site criteria. Consequently, the project would cover two main subjects:

• Mix designs for adequate performance; and
• Quality management systems during construction.

It was agreed that the study should differentiate between intersections and open road conditions, as different performance criteria applied to these varied zones. Other issues discussed included:

• Balancing crusher sand content with availability (i.e. reducing the -4.75mm fraction which frequently exceeds 60%) and hence the desirability of moving to stone skeleton mixes (as opposed to sand skeleton ones);
• Matching layer thickness with the NMAS;
• The need to understand and incorporate methods to assess aggregate packing e.g. the “Bailey Method” as published by Transportation Research Board (TRB);
• COLTO gradings would NOT be a point of departure.

The process would entail a joint venture between the road authority, consultants and suppliers/contractors to enhance the expertise base and, ultimately, to advance the implementation of innovative methods.

Designs based on generally available standard binders were submitted in July, to be used on trial sections of 60 tons (160m x 3.7m x 40mm) to be provided and laid at no cost to GPTRW.

Prior to commencement of accelerated pavement testing (APT) early in 2007, a “standard” mix would be subject to MMLS and laboratory testing to offer a benchmark against which the new candidates would be measured.

Innovative designs

The following mix designs have been submitted:

• Black Top Surfaces/Atlas Asphalt using chrome slag from SAMANCOR, Witbank – a single design for both open highway and rut resistant applications;
• Much Asphalt/Vela VKE (West Rand) – one design each for open highway and rut resistant applications;
• Much Asphalt, Rand Roads, Vela VKE and Arcus Gibb (East Rand) — one design each for open highway and rut resistant applications.

The mix designs submitted by Much Asphalt, Rand Roads, Vela VKE and Arcus Gibb are all based on the Bailey Method to ensure proper aggregate packing and adequate binder contents. Akasia Asphalt is changing its aggregate source and will submit a design for rut resistant mixes at a later stage.

As reported in the last issue of Asphalt News, the group raised concerns that COLTO grading envelopes were probably no longer relevant to current performance expectations, nor to aggregate gradings and shape. Adopting these gradings inevitably leads to low binder content or low voids in the mix, or both, which may yield premature brittleness and lack of resistance to permanent deformation.
Therefore, the COLTO gradings were not used as a point of departure for the designs submitted. Instead, in four cases, the Bailey Method (see box) was utilised to develop initial aggregate proportioning. It was agreed that all the designs be reviewed on the basis of comments from the meeting before being finalised.

High modulus asphalt

Encouraged by progress made with the make-over of hot mix asphalt, it was agreed in principle to include high modulus asphalt (HiMA) in the APT testing programme.

A requirement would be that the HiMA meet required performance criteria based on overseas experience. Shell and Sasol Wax have both indicated their interest in supplying a suitable binder, and will be invited to attend the advisory group’s next meeting and to submit mix designs, based on the French EME technology, that meet the design criteria.

The design, supply of material, construction of test sections, laboratory testing and analysis, and analysis of APT results will be carried by the participating companies in association with Sabita, while GPTRW will bear the costs of APT testing. It is anticipated that the HiMA sections will be constructed in May 2007.

If the translation of the technology to SA is successful, road owners and airport companies will be presented with an alternative layer to assess in the interests of cost-effectiveness.

A model for future cooperation

The next meeting of the IAG is scheduled for Tuesday 3 October 2006 when acceptance of revised designs will be reviewed prior to construction of the trial sections.

This joint venture presents a model for future cooperation between road authorities, suppliers, contractors and consulting engineers to mobilise experience and expertise in response to technical challenges, as well as a springboard for future initiatives in innovative HMA products.

What is High Modulus Asphalt?

A French initiative Énrobé à Module Élevé (EME) – locally called HiMA — is defined as a base course:

- with a high binder content in the region of 6% bitumen, with corresponding low air voids (1.8% 120 gyrations);
- which utilises hard grades of refinery produced bitumen (15/25 pen: R&B SP66);
- consisting of aggregates with angularity and cleanliness defined;
- with high elastic stiffness and complex modulus of 14 GPa (15°C, 10 Hz);
- with high deformation and good fatigue resistance;
- which is permeable and durable due to high binder content.

HiMA has been used in France for 20 years and was tested in the UK by the Transport Research Laboratory (TRL) in 2005 (Report 636). TRL concluded that, compared with the UK heavy duty macadam, EME (HiMA):

- was more deformation resistant;
- had superior load spreading capability while being more durable and impermeable;
- enabled a reduction in layer thickness – 25mm in the high traffic range.

The Bailey Method

Published as TRB Circular E-C044 (2002), the Bailey Method for Gradation Selection in Hot-mix Asphalt Mixture Design presents a systematic approach to blending aggregates that provides aggregate interlock as the backbone of the structure and a balanced continuous gradation to complete the mixture.

The method enables the designer to define coarse and fine aggregate and adopts a principle of aggregate packing in which the coarse aggregates create voids to be filled by the fine aggregates.

Aggregate proportions are determined on a volume basis.

Analysis of blends:

Two basic mix types are defined:

- Coarse graded – where the load is carried by the coarse aggregate skeleton;
- Fine graded – where the load is carried by the fine aggregate (sand) skeleton.

A number of aggregate ratios need to be met to ensure packing is as intended and is not interfered with.

Industry Advisory Group:

Elzbieta Sadzik (GPTRW), Piet Myburgh (Sabita), Kobus de Jager (Akasia Asphalt), Arthur Taute (Vela VKE), Gary Catin (Rand Roads), Gert Koen (Black Top Surfaces), Mike Kohlberg (Rand Roads), Ron Berkers (GPTRW), Herman Marais (Much Asphalt), Nico Wilcocks (Atlas Asphalt), Joe Grobler (Vela VKE), Gert Mynhardt (Akasia Asphalt), Derek Pretorius (Arcus Gibb), Connie Shongwe (Arcus Gibb), Les Sampson (Sampson Consulting), Benoit Verhaeghe, (CSIR).
Sabita’s undertaking to ensure the implementation of appropriate safety training in the bituminous products sector kicked off in June and July when 19 employees of member companies took part in BitSafe Train-the-trainers courses in Stellenbosch, Johannesburg and Durban.

BitSafe is a course on the safe handling of bitumen, developed to increase the awareness of the hazards and risks associated with the handling and testing of bituminous binders. The modular format of the course facilitates training while limiting impact on production, and the intention is that all employees involved in the handling of bitumen throughout the supply chain should complete all 13 modules within a two-year period.

Training the Trainers

The inaugural three-day Train-the-trainers courses were attended by employees from Black Top Surfaces (2), BP SA (2), Colas SA (1), Engen Petroleum (1), More Asphalt (1), Much Asphalt (6), Phambili Surfacing (1), Polokwane Surfacing (1), Power Construction Roads (1), Tosas (2) and Zebra Bituminous Surfacing (1).

“It is essential that trainers nominated by member companies have both hands-on experience with the handling of binders, and presentation skills,” according to Sabita’s Trevor Distin. “The main focus during the Train-the-trainer course is to develop the skills which will allow trainers to effectively administer the BitSafe modules at their place of work. The real challenge for these trainers will be to train their work colleagues while fulfilling their normal daily tasks. The support of senior management will therefore be crucial to achieving overall company objectives of worker safety and well-being.’

Certification

During their training presentations, BitSafe trainers will have the support of training aids such as DVD’s, training manuals, prepared slide presentations and posters. They will also be required to conduct assessments after each module and on completion of all the modules the trainees will receive a joint Sabita/Asphalt Academy certificate.

‘We are encouraged by the initial response of our members in support of this initiative to improve the level of safety awareness in our industry,” Distin said. “We have to acknowledge, however, that there are probably more than 2,500 employees involved in the pumping, loading, transporting, offloading, heating, spraying, mixing, sampling and testing of bitumen on every day.

“Ensuring that all of these people have been properly trained in safe working procedures when handling bitumen will therefore be a long job, and we urge all employers, from those who refine bitumen through to those who fill potholes, to implement the BitSafe training scheme within their companies.

“Any intermediaries involved in transporting or transferring bitumen into containers on behalf of employer companies should be included in this process, since they are probably most at risk of succumbing to an safety incident,” Distin added.
Requirements of a BitSafe trainer

Each nominated BitSafe trainer should meet the following criteria.

1. Work experience: The candidate should have practical and technical industrial experience and knowledge relating to:
   - Manufacture of bituminous products;
   - Application of bituminous products;
   - Handling of binders;
   - Health and Safety practices in the work place;
   - Use of PPE, first aid and fire fighting equipment.

The above are prerequisites for attending the Train-the-trainer course.

2. Training experience: While the applicant may not readily have prior training experience, the course requires that the trainer have the capacity to develop and acquire the following skills:
   - Good understanding of:
     - Training methodology for adult learners;
     - Group facilitation techniques.
   - Delivery of training interventions at the work place. The trainer must be able to effectively:
     - Plan, organise, administer and keep records;
     - Use training aids including PowerPoint;
     - Assess and evaluate the learners.

3. Communication skills: It is imperative that the trainer have good interpersonal and presentation skills, and have the ability to:
   - Speak English and a second language;
   - Use good non-verbal skills;
   - Relate theory to practical work situations and examples; and
   - Train in a variety of situations and localities.

Modified binder specifications and TG1 to be updated in line with local and overseas experience

The Road Pavement Forum task team under the chairmanship of Dennis Rossmann has been reconvened to review the current specifications for modified binders.

These were originally published as a best practice guideline known as TG1, under the auspices of the Asphalt Academy in 2001, and replaced the outdated specifications contained in the COLTO document. However it is recognised that while TG1 is a best practice guideline for the selection and use of modified binders, it does not constitute a specification.

To have a legal basis, a specification should fall under the ambit of a body like SABS. The same will apply to the test methods contained in the current TG1 document, and the Road Materials Committee will therefore be asked to approach SABS about incorporating the modified binder tests into the list of SANS test methods for road materials.

With the ongoing developments in the field of modified binder technology, it has become necessary to update the current specifications in line with overseas and local experience.

Two task team meetings have been held so far this year, and already specific items have been identified for further investigation following a review of the recently formulated European Union CEN and Australian specifications.

Some of the new developments that are being investigated by the task team members are:
   - The feasibility of having a seamless testing regime for polymer and bitumen rubber binders;
   - A low temperature adhesion test for binders used in seals;
   - A durability test to measure long term performance of modified binders;
   - Expand the specification to incorporate Fischer Tropsch wax modified binders for use in rut resistant asphalt mixes;
   - The use of cutters to reduce the incidence of low temperature brittle fracture;
   - Development of protocols for:
     - Heating of modified binder samples;
     - Conducting asphalt mix designs using modified binders;
     - Introducing a new modified binder.

A revised specification and TG1 guideline document should be available by the end of 2007.
After some decades of arbitrarily assigning hot mix lift thickness (t) to nominal maximum aggregate size (NMAS), it was interesting to note an article in NAPA’s HMA
t magazine by Ray Brown, Director of NCAT, on the outcome of studies completed for NCHRP 9-27. This article proposes relationships of t and NMAS based on data developed during compaction trials adjacent to the reconstruction of the 2003 NCAT test track.

As is the case here, various construction guidelines in the USA proposed different ratio’s of t to NMAS. These guidelines were based more on current practice than on documented research.

Project 9-72 was funded to develop data to determine the recommended thickness to nominal maximum aggregate size. Seven sections were built with varying thicknesses and mixtures consisted of various NMASs (ranging from 9.5mm – 19mm), gradations and mix types.

For each of the seven sections, being 40 m in length and 3.5 meters wide, 12 test locations were identified for taking cores for density and thickness determination.

Placement of the sections provided for t/NMAS ratios ranging from 2 to 5, compacted in a consistent manner with an 11-ton steel drum roller, 2-meters wide, that could operate in vibratory or static mode.

Typical field density data at various t/NMAS ratios are shown in the figure below. The density that can be obtained under the “normal rolling conditions” adopted is clearly related to the t/NMAS ratio.

It is recommended that t/NMAS be at least 3 for fine-graded mixes and at least 4 for coarse-graded ones. While ratios less than these proposed values can be adopted, cognisance should be taken of the fact that more compactive effort would be required to achieve the target density.

![Graph showing density vs. t/NMAS ratio]

**Conferences**

**Dresden conference on bitumen fumes**

Together with global stakeholders such as Eurobitume, EAPA, The Asphalt Institute and NAPA, Sabita was a co-sponsor of an international symposium held in Dresden in June this year, when expert scientists presented peer reviewed papers on, *inter alia*, epidemiological and inhalation studies of bitumen fumes.

Co-organised by the American Conference of Government Industrial Hygienists (ACGIH) and the Deutsche Forschungsgemeinschaft (DFG), it is believed this conference will assist the International Agency for Research into Cancer (IARC) to incorporate current knowledge into a monograph on bitumen fumes, expected to be issued in September this year.

The symposium outcomes will be supported by a €2.2-million IARC study to examine the contribution of confounding factors such as past exposure of workers to coal tar fumes and vapours, and contributing lifestyle factors.

**CAPSA’07**

The first details of CAPSA’07, to be held at the Gaborone International Conference Centre in Botswana from September 16-19 2007 have been released.

The programme will be structured into plenary presentations in the focus areas, supported by parallel, workshop-style sessions. Focus areas will include:

- Hot mix asphalt;
- Surface seals;
- Bituminous stabilisation;
- Component materials;
- Structural design
- Asset preservation
- Delivery
- Occupational health, safety and the environment