ASPHALT DESIGN METHOD FOR SA

Sabita – SAT Workshop
18 November
Pretoria
Programme

1. *Introduction*  
   P Myburgh

2. *Mix Type & Selection*  
   B Verhaeghe

3. *Binder & Aggregate Selection*  
   H Marais

4. *Mix Design & link with Pavement Design*  
   J Anochie-Boateng

5. *Quality Management*  
   J Grobler
Introduction - content

- Initiation
- Project framework
- Objectives
- Scope of method
- Features
- Process of implementation
Initiation

**Drivers**
- SARDM
- Limited validation of technology proposed in IGDHMA (2001)
- Innovation in asphalt production (WMA, RA and EME)
- International and local advances in technology.
- The increased volumes of heavy vehicles on SA roads

**Framework**
- Developed in Dec 2009
- Informed by SARDM
- Inform COTO specification

**Research contract Sabita – CSIR 2010**
- Essentially consisting of 3 phases
Project framework

- Phase I: Establishing project management structure (Sabita TDFP)
- Phase II: Evaluation of current design methods.
  Literature study to assess gaps
  Consultation with industry experts
- Phase III: Experimental work and manual development
Objectives

- *Manual* will replace existing *guidelines* for the design of asphalt mixes in South Africa
- Move from *empirical* -based to – *performance related* design of asphalt
- Methods in line with international best practice
- Enable the formulation of *national specifications*
Document scope

- Mix type selection
- Binder selection
- Aggregate section
- Mix design procedure
- *Link with pavement design*
- Quality assurance/control
Special features of the method

- Mix type selection
- Multi-level design approach (risk associated)
- Resistance to permanent deformation
- Link with pavement design
- Quality assurance
Mix type selection

• Classification based on *aggregate packing*
  • Instead of gradings
  • Typifying mixes in terms of grading type does nothing for indicating how they carry loads and distribute stresses
• Mix types based on *skeleton structure* (as per SAPEM)
  • Stone skeleton
  • Sand skeleton
• Gradings a secondary property
  • Suited for *quality control*
  • No more generic types e.g. COLTO fine/coarse etc.
  • Suggested control points for sand skeleton mixes (most common)
    • MPS – layer thickness
    • 2mm & 75 μm sieves
• Bailey method recommended - optimise mix composition (Franckken, Olard)
Sand and stone skeletons

Sand skeleton mix

Stone skeleton mix
Classification of mix types

- Stone skeleton
  - Open graded
  - SMA
  - Coarse graded
  - Ultra thin

- Sand skeleton
  - Gap graded
  - Semi-gap graded
  - Fine continuous
Multi-level approach

**Level I:**
Low risk of structural damage
≤ 3 million ESALS
- Recommended control points for aggregate grading selection
- Volumetric design with mechanical properties testing

**Level II:**
Medium to high risk of structural damage
3 - 30 million ESALS
- Level I volumetric design
- Performance related laboratory testing to select optimum mix design

**Level III:**
High risk of structural damage
> 30 million ESALS
- Level I volumetric design, and full scale laboratory testing
- Establishes full scale laboratory data for advanced pavement design and analysis
Permanent deformation - Flow number

- Level II and III design
- Compacted asphalt specimens subjected to a controlled sinusoidal compressive loading.
- Confining stress option
- Permanent axial strain is measured as a function of the number of load cycles.
- Flow number - number of load cycles corresponding to the min permanent strain rate
- A higher flow number indicates a more rut-resistant mix.
Flow number, $F_n$
Avoiding pitfalls of the past

• COLTO gradings
  - Striving for max denseness at the expense of adequate binder films (due to change in general aggregate shape since development of these gradings)
  - Neither sand, nor stone skeletons (packed with interceptors)
  - Engineering properties not optimised
  - Studies in SA showed that optimum mixtures did not comply with COLTO.

• Marshall properties
  - Adherence to compliance limits/ratios with little if any link to performance
  - Original purpose to avoid mixes that were over-rich in binder

• Scope for inexperienced designers
  - Holding fast onto the security blankets – conflict with best practice
  - Manufacturers hamstrung to offer optimum designs
  - Leave design to those whose well being depends on good quality
Rut Challenge – Gautrans/Sabita 2008

**HMA mix grading**

- **After RTFOT Softening Point (°C)**
  - **Design**
  - **Much Field Mix Results**
  - **Actual HMA - truck**
  - **Actual Core -1 month**
  - **Actual Core -1 month**
Rut resistance

• Tells us two things:
  • Aggregate packing has a major role on performance
  • Binder grade perhaps less so
Grading control points

- Grading is influenced by choices:
  - Layer thickness – max aggregate size
  - Packing type – sand or stone skeleton

Figure 4.1: Grading control points plotted on 0.45 power chart for MPS = 14 mm
Link with pavement design (under construction)

- SARDM requires response & damage models
  - Dynamic modulus
    - Witczak prediction
    - Hirsch prediction
    - Laboratory tests
  - Asphalt damage models
    - Permanent deformation
    - Fatigue fracture
Special mixes

- Cold mixes – Sabita Man’s 14, 21 and TG2
- Porous asphalt – Sabita Man 17
- Light traffic (residential areas) – Sabita Man 27
- WMA – Sabita Man 32
- EME – Sabita Man 33
- Mixes with RA – TRH 21
- SMA – Appendix of the design manual
Notes on special mixes - SMA

• SMA - essentially a binary system (stone skeleton type)
  • *self-supporting* stone structure (>2 mm) throughout layer
  • *partially* filled with binder-rich mastic.

• Stone skeleton is kept in place by the adhesion and cohesion of the mastic (i.e. the binder and the mineral aggregate finer than 2mm).

• The stone skeleton should *not be dilated* by the mastic
  • $VCA_{\text{mix}}$ i.e. the volume in between the coarse aggregate particles, comprising filler, fine aggregate, air, binder, and (where used) fibre should be less than the VCA of the dry aggregate

• Filler-bitumen system is overfilled

• Gradings do not guarantee these requirements
Notes on special mixes - EME

• Components
  • Hard, unmodified bitumen (10/20 and 15/25 penetration grades)
  • Blended at high concentrations (up to 6.5% m/m)
  • Good quality, fully crushed aggregate
  • Low air voids content

• Key performance characteristics are:
  • High elastic stiffness
  • High resistance to permanent deformation and fatigue failure
  • Good moisture resistance and good workability
  • Superior load spreading ability

• Grading curves
  • point of departure for the mix design process
  • not be used to impose a restriction on the grading
QA approach

- Level I - Volumetric design
  - A mix design is usually tendered for each contract and client or consultant approval is obtained for the mix design.
- Level II and Level III - Performance-related designs.
  - New approach
  - Relatively lengthy laboratory testing procedures
  - Repeat of such designs on a contractual basis impractical
  - Proposed - suppliers would have a number of performance-related mixes “certified” for specific applications and performance expectations
  - Valid for two years – provided no significant changes to the raw materials
  - Where a performance-related mix is not certified ‘certification-type’ testing procedure precedes the quality control process, so the same quality control approach is still followed.
## QA processes

<table>
<thead>
<tr>
<th>Level I</th>
<th>Levels II, III</th>
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<tbody>
<tr>
<td><strong>Contract based mix design</strong>&lt;br&gt;• Aggregate properties, grading, binder content, VIM, MVD, VMA, VFB, BD, ITS, dynamic creep, durability and permeability</td>
<td><strong>Certified mixes (or purpose designed mixes)</strong>&lt;br&gt;• Aggregate properties, grading, dynamic modulus, fatigue, permanent deformation, workability, durability, binder content, binder MVD and VIM</td>
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<tr>
<td><strong>Plant mix and trial section</strong>&lt;br&gt;• Binder content, grading, VIM, MVD, VMA, VFB, compaction density</td>
<td><strong>Trial section</strong>&lt;br&gt;• Grading, binder content and VIM/field density</td>
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<td><strong>Field/Site</strong>&lt;br&gt;• Binder content, grading, VIM, compaction density, layer thickness&lt;br&gt;• Frequency of sampling and acceptance limits are defined in the relevant specifications</td>
<td><strong>Field/Site</strong>&lt;br&gt;• Grading, binder content and VIM/field density&lt;br&gt;• Paving – QC: compaction, temperature control and limiting segregation</td>
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Implementation (Interactive process)

- Asphalt mix design workshop Midrand Feb 2012 – affirmed the proposed project
- Interaction with RPF (May 2011, May 2013,)
- Sabita TDFP (industry, consultants, research, clients) Review May 2014
- SAT – Sabita Workshop 18 November 2014
- Final review by Sabita TDFP
- Publication
Notes

- Introduction of the PG specifications - requires changes
- Terms such as AE-1, AP-1 will ultimately go
- COLTO type gradings are not a requirement
- *Expertise resides with producers who should produce (and certify) designs for a variety of applications*