Sabita premix design manual

Progress report

24th ROAD PAVEMENTS FORUM

CSIR International Convention Centre, Pretoria

6 & 7 November 2012

Joseph Anochie-Boateng

CSIR Built Environment

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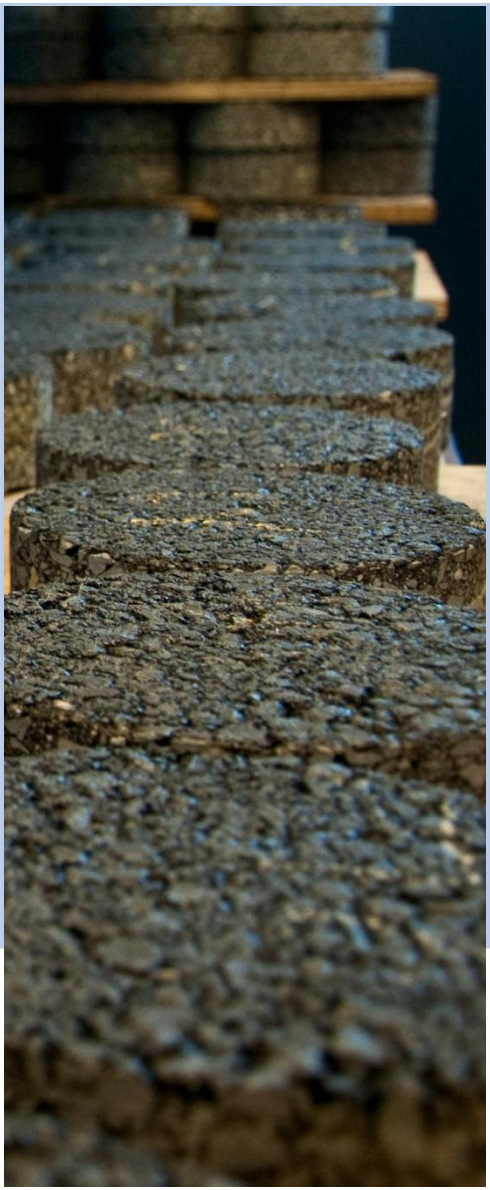
Acknowledgements



- Southern African Bitumen Association (Sabita)
- National Asphalt
- Much Asphalt
- CSIR Built Environment
- CSIR HMA Group
  - A Crawford, B Verhaeghe, C Fisher, D Ventura, G Mturi, J Maina, J O'Connell, J Anochie-Boateng, J Komba, K Makamu, T Nkgapele

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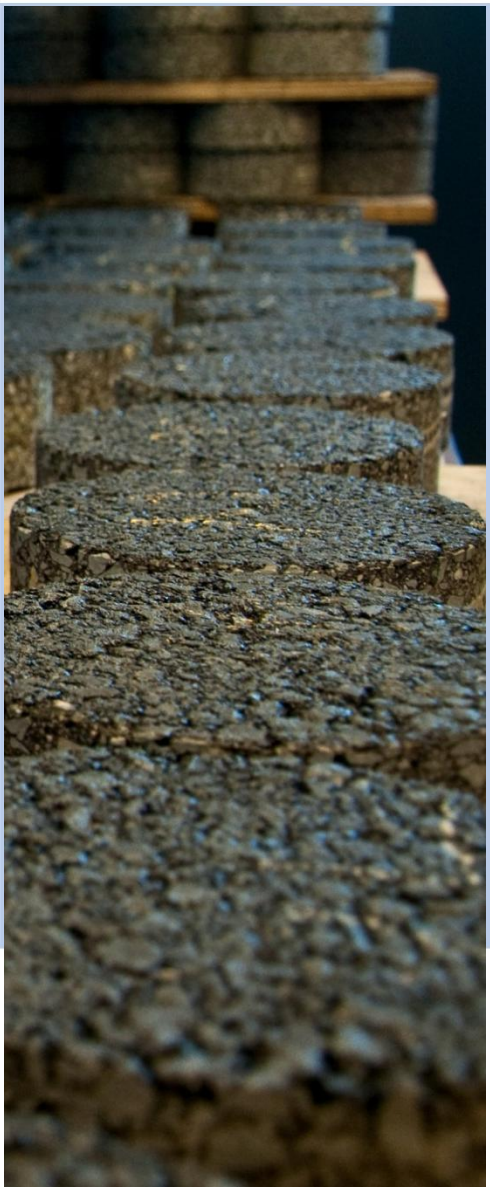
Manual project



- Phase I: Establishment of a project management structure (Inception report- Denneman & Verhaeghe, 2011)
- Phase II: State-of-the-art review with recommendations (Denneman et al 2011)
  - Workshop held in February 2012 to present the findings of phase II to stakeholders from the industry
- **Phase III: Experimental work and development of the design manual**
- **Phase IV: Dissemination and entrenchment into practice**

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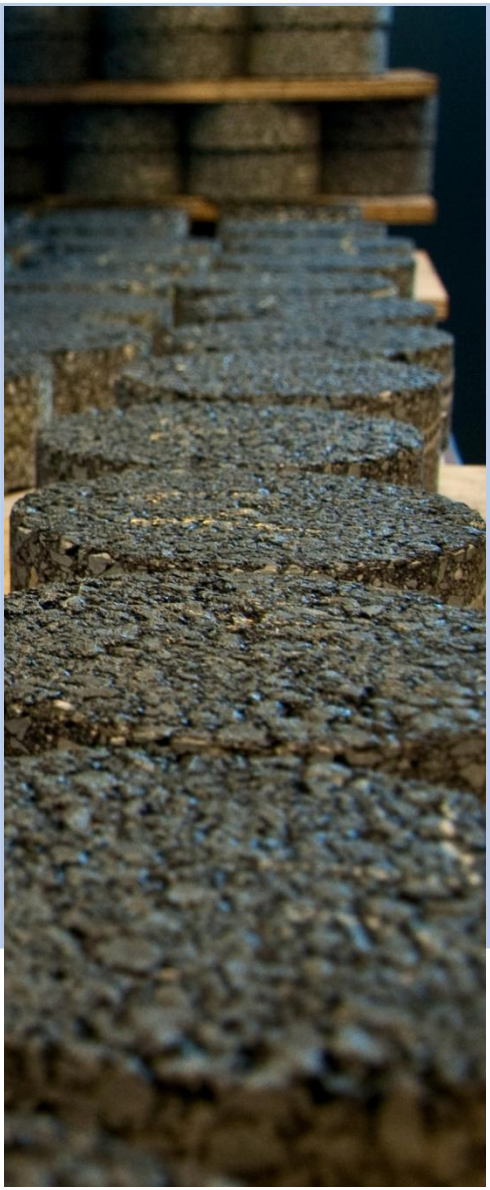
Important milestones



Activity	Completion date
1. Phase I (Establishment)	30 Dec 2011
2. Phase II (State-of-the-art study)	31 July 2011
3. Laboratory testing to develop criteria (seven aggregates, 13 mixes)	**21 Feb 2013**
4. First draft design manual	**31 March 2013**
5. Send draft manual for review – local & international reviewers	**15 April 2013**
6. Organize workshops	**xx May 2013**
7. Comments/suggestions from reviewers	**15 June 2013**
8. Incorporate comments/suggestions	**15 July 2013**
9. Phase IV (Dissemination)	xx xxx xxxx

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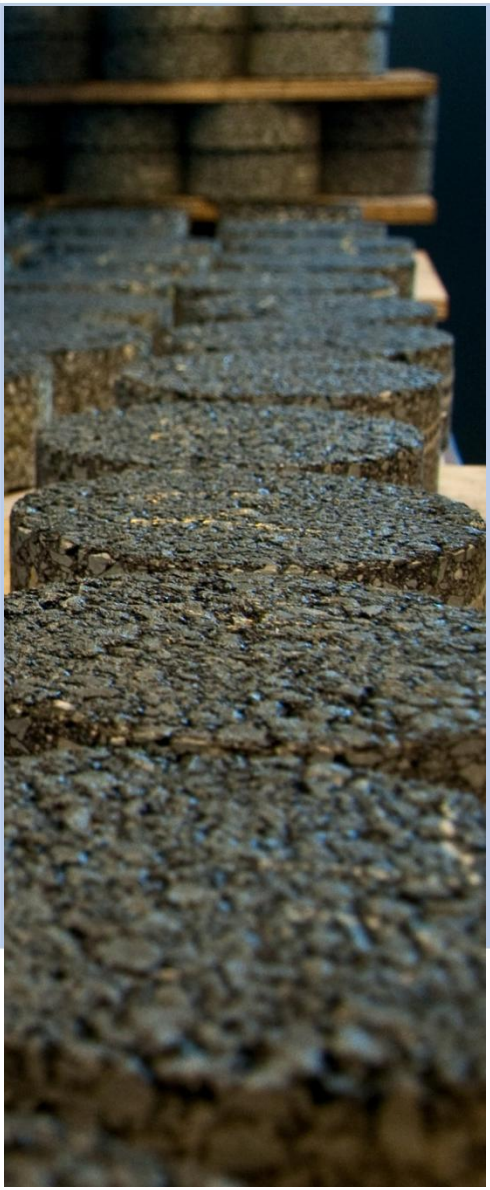
Why new manual?



- New and revised pavement design methods (e.g., SAPDM)
- Increase in the application of non-conventional hot-mix asphalt (e.g., warm mix, cold mix, recycled asphalt, HiMA…)
- Increase in volumes of heavy vehicles/traffic on SA roads
- Demand for higher performance mixes
- International and local advances in asphalt technology
- International trend towards performance related mix design methods (EU, US, AUS)

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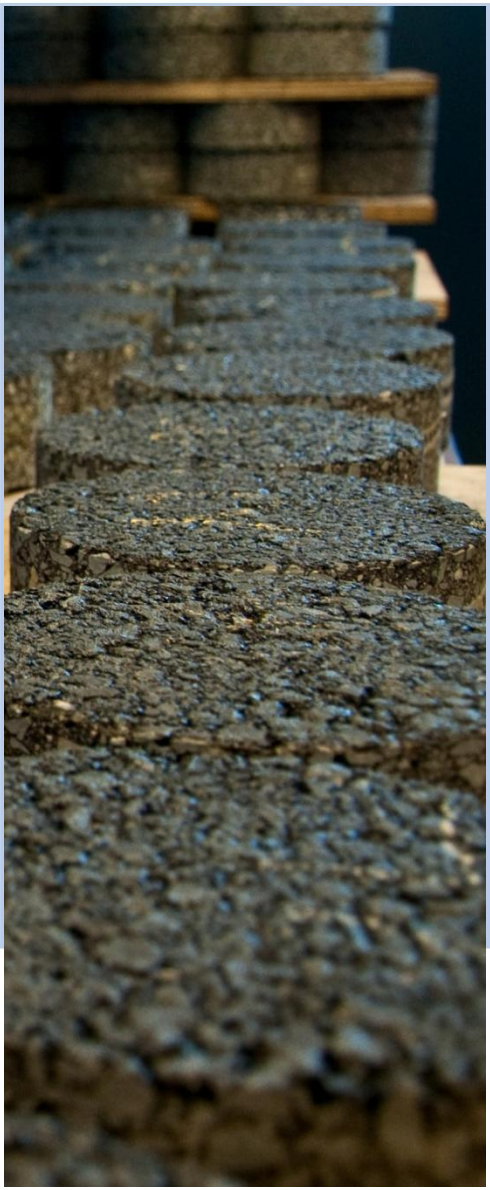
Objectives



- Bring mix design in SA in line with current state-of-the-art
- Complete the migration from empirical-based to performance related mix design

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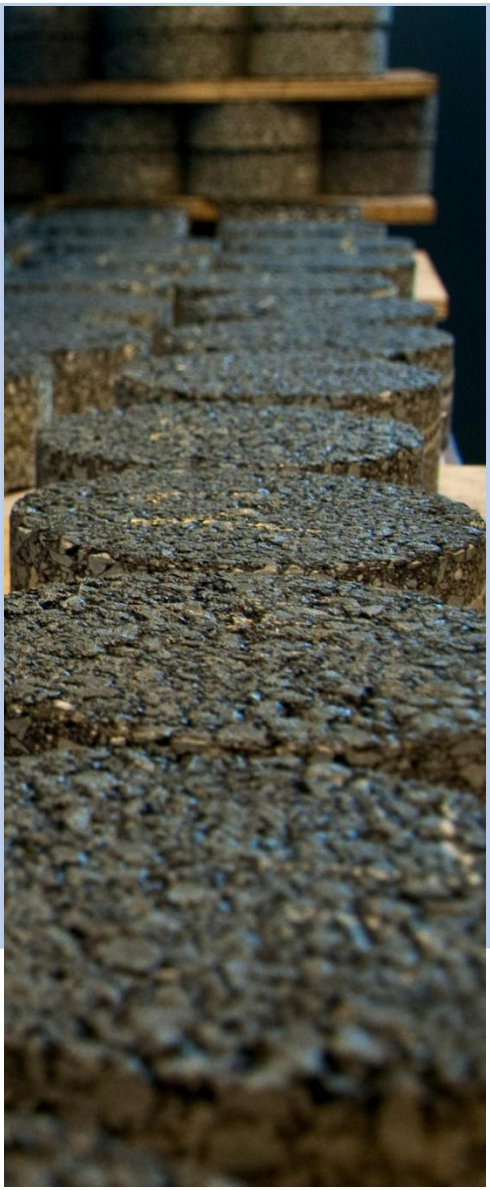
Tasks – Phase III



- Select seven commonly used natural aggregates in road construction in SA
- Prepare eight Sabita HMA mixes selected from provinces other than Gauteng
- Prepare five mixes similar to SANRAL GFIP mixes
- Conduct performance related laboratory tests on all 13 mixes, determine performance-related properties, and set criteria
- Develop the premix design manual
- Submit draft chapters as separate deliverables
- Complete Manual (draft) by the end of March 2013

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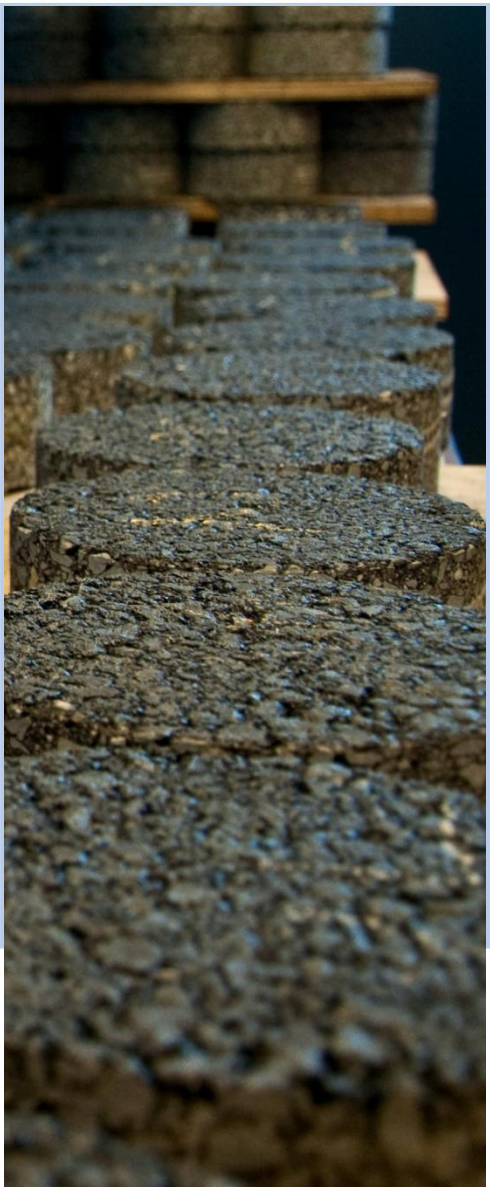
Contents of the manual



Chapter	Topics to be covered
1. Introduction	▪ What is asphalt? ▪ History of asphalt mix design in SA ▪ Scope of the asphalt mix design manual ▪ Mix design philosophy ▪ Changes compared to interim guidelines of 2001 ▪ Alignment with international state-of-the-art
2. Mix Type Selection	▪ Properties of asphalt mixes used in SA ▪ Structural requirements ▪ Functional requirements
3. Binder Selection	▪ Step by step approach to selection of binders ▪ Interim SA performance grade (PG) binder selection procedure ▪ PG binder specifications proposed for the SA environment

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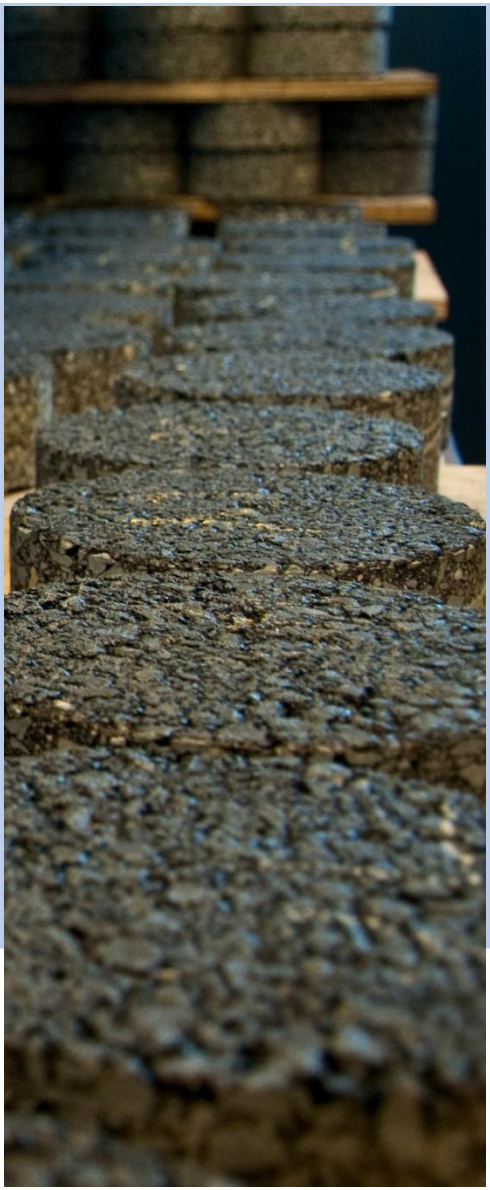
Contents of the manual



Chapter	Topics to be covered
4. Aggregate Selection	▪ Aggregate selection ▪ Mineral filler selection ▪ Aggregate packing analysis (Bailey method)
5. Mix Design	▪ Volumetric design ▪ Conventional asphalt mix design process ▪ Modified conventional design process ▪ Performance related design process ▪ Performance criteria for different mix types ▪ Additional requirements for SMA, cold mix, warm mix, recycled asphalt, friction courses)

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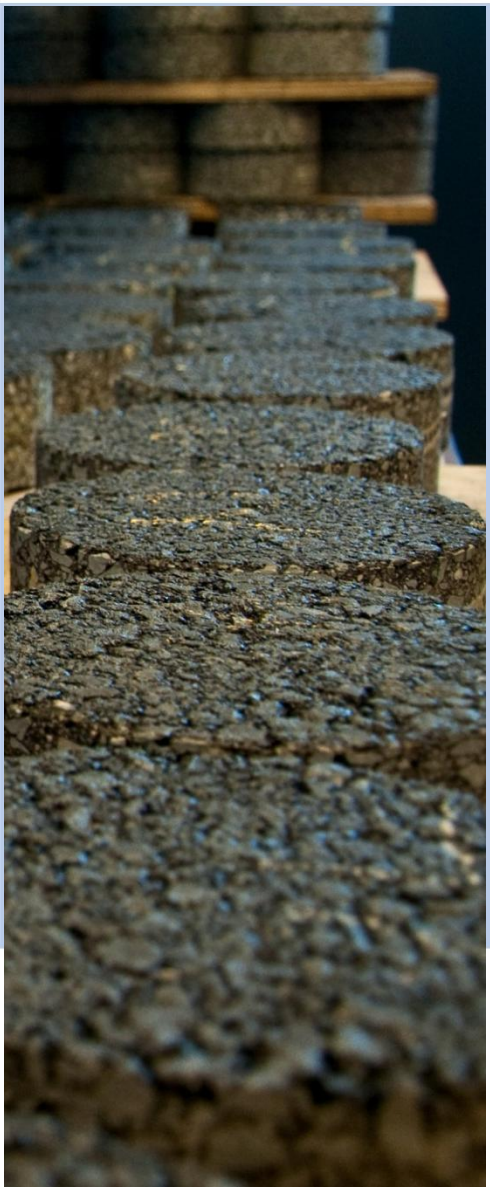
Contents of the manual



Chapter	Topics to be covered
6. Asphalt Pavement Design	▪ Traffic and pavement structure to determine strain levels ▪ Master curves ▪ Predictive models (damage) ▪ Incorporation of new design concepts such as long life and airport pavements
7. Quality Control	▪ Traditional Lab designs (contract-based) and associated QC ▪ Certified mixes based on performance tests. QC to incorporate binder content, grading, binder stiffness, aggregate properties

Aim to have preliminary draft Manual completed by 15 Dec 2012

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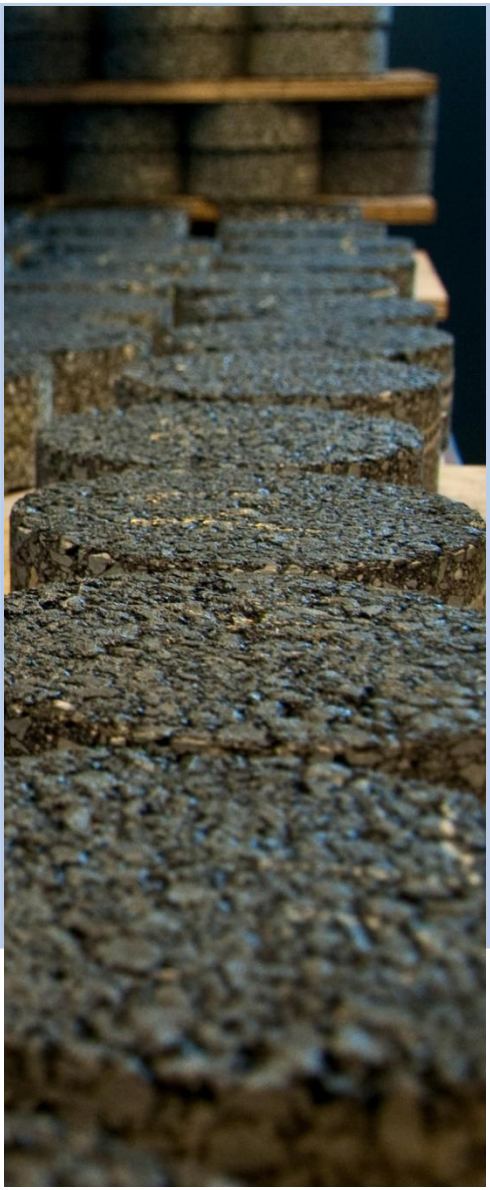
What is new in this manual?



- Performance-based binder selection
- Bailey method for aggregate packing analysis
- Superpave gyratory compaction method
- Performance-based testing
- Criteria to select mixes based on performance related laboratory tests

…The manual is performance-based; laboratory testing and evaluation procedures aim to closely simulate field conditions…

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Binder selection

- Performance grade binder specification, based mostly on updated US SUPERPAVE
- Select binder for project specific traffic and climate conditions
- Dynamic shear rheometer (DSR) the main piece of equipment used in binder testing
- Modified/unmodified binders to be assessed using the same specification
- Project to validate use of PG for SA binders is essentially completed
- Workshop proposed for 29 Nov 2012 to finalize PG specifications

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Aggregate selection

- Andesite, dolerite, granite, hornfels, norite, quartzite, tilite
- Design grading and analysis of aggregate blend will be based on the Bailey method
- Criteria will be set based on UW & CA, FA_c, FA_f ratios

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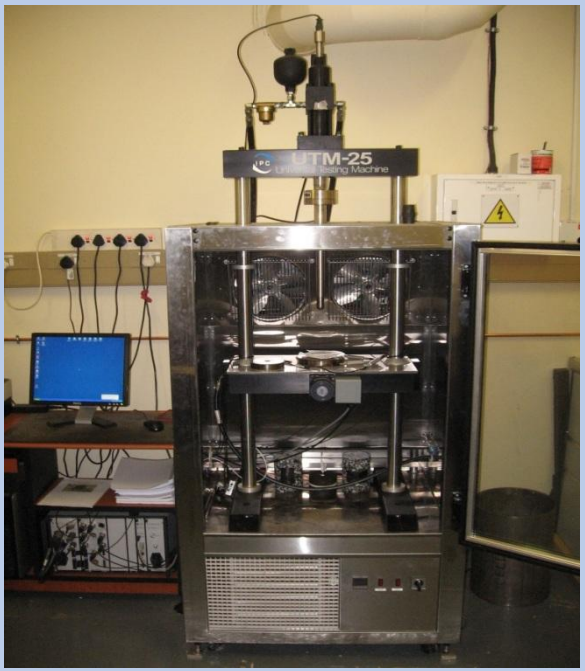
Mix design: performance-based

- Volumetric design
- Compaction: gyratory compactor
- Laboratory testing: performance-based



Shear tester

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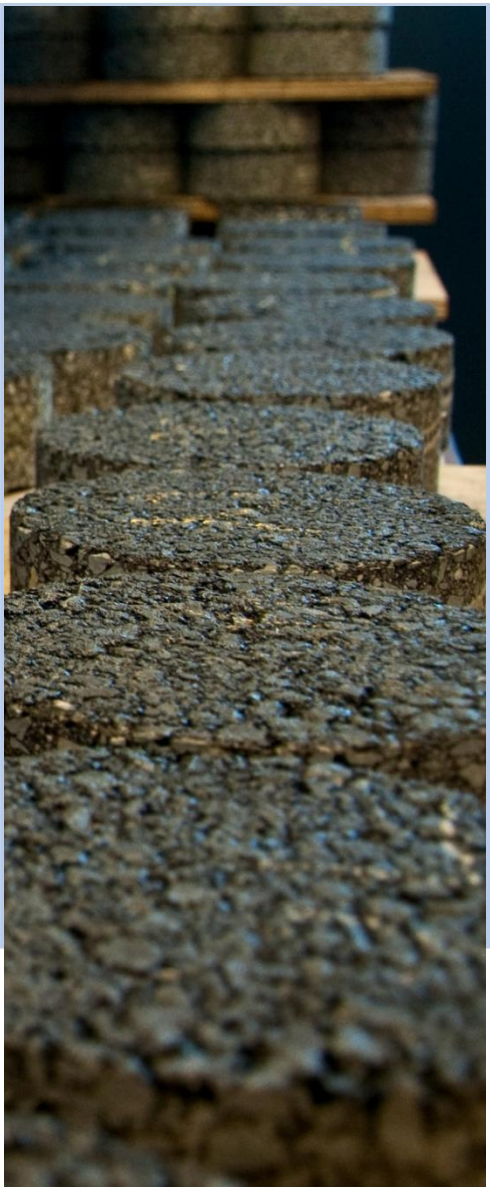
Mix design – modified conventional



Select mix type

Design objectives	Design situation

Evaluate components

Selection of performance grade binder	Selection of suitable aggregate

Grading selection

Aggregate packing analysis	Grading envelopes (criteria)

Optimum binder content determination

Marshall/gyratory effort by traffic category	Determinants: BRD, Stability, Voids

Check empirical criteria

Stability, flow, stab/flow ratio, VMA, VFB, voids	Optional: Dynamic creep, ITS, static creep, immersion index, permeability, modified Lottman

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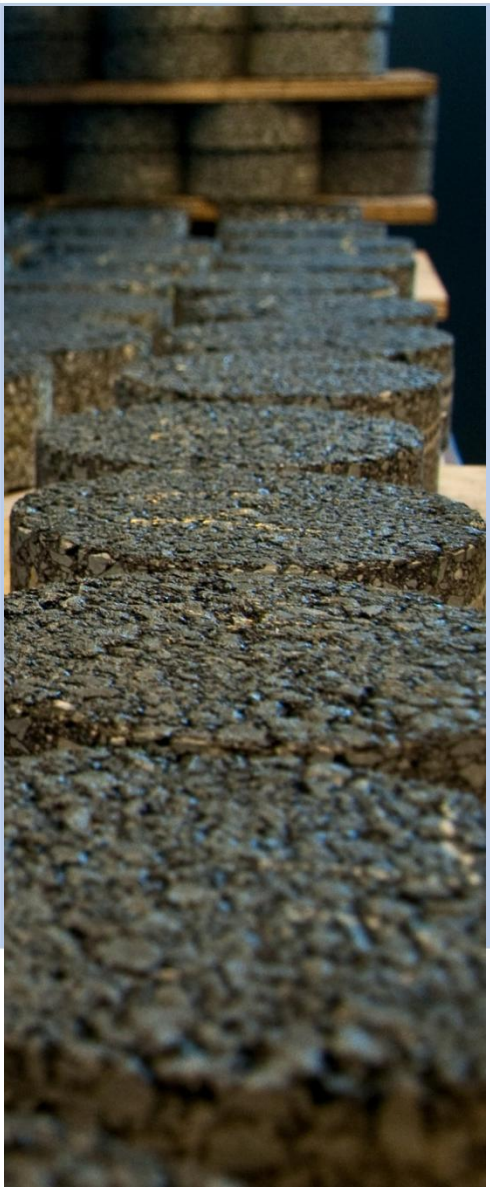
Mix design – performance based



Select mix type

Design objectives	Design situation

Evaluate components

Selection of performance grade binder	Selection of suitable aggregate

Select trial grading curves

Aggregate packing analysis	Grading envelopes (guideline)

Select trial binder contents

Minimum film thickness (guideline)	Minimum binder content (guideline)

Produce trial mixes, select optimum design

Criteria: workability, stiffness, permanent deformation, fatigue, durability, permeability.

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Mix design – Laboratory study

- Five mixes similar to GFIP mixes (SAPDM)
- Eight Sabita mixes:

1. BTB + AP-1
2. WC medium continuous + 50/70
3. Durban Type A medium continuous + 50/70
4. Durban Type D + recycled asphalt + 50/70
5. Durban Type D + WMA additive + recycled asphalt + AE-2
6. Medium continuous + AP-1
7. Porous asphalt + BR
8. SMA + AP-1

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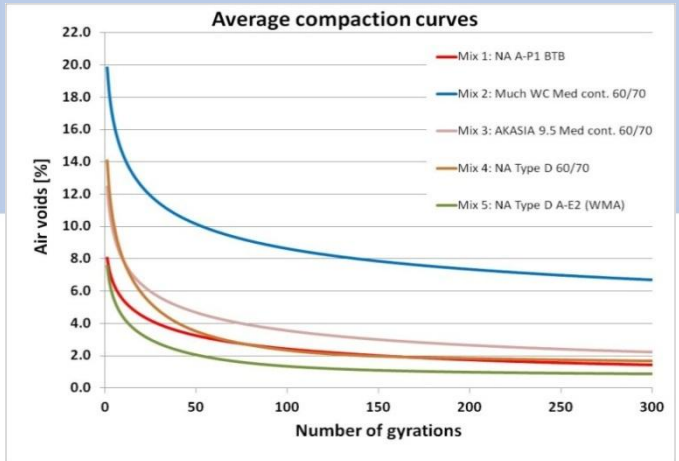
Workability



- Relate workability in the gyratory compactor to compactability in the field
- Superpave gyratory compaction method will be followed (ASTM D6925)
  - Gyratory compaction curve data (gyration angle of 1.25 , 30 gyrations/minute, 600kPa applied vertical pressure)
  - Sample dimensions (150 mm in diameter x 170 mm high sample)
- Criteria will be set based on voids content @ specified number of gyrations

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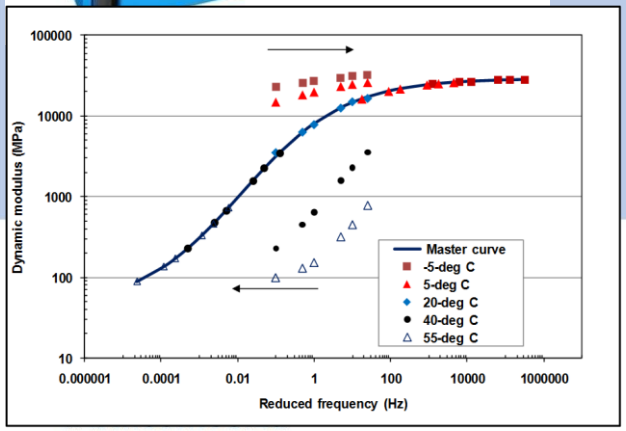
Dynamic modulus



- Asphalt mixture performance tester (AMPT) dynamic modulus, AASHTO TP 79 /CSIR protocol for SAPDM
  - Five temperatures of -5, 5, 20 40 55 C, and six frequencies 0.1, 0.5, 1, 5, 10, 25 Hz
  - Criteria be set based on the dynamic modulus values @ pre-determined temperature and frequency

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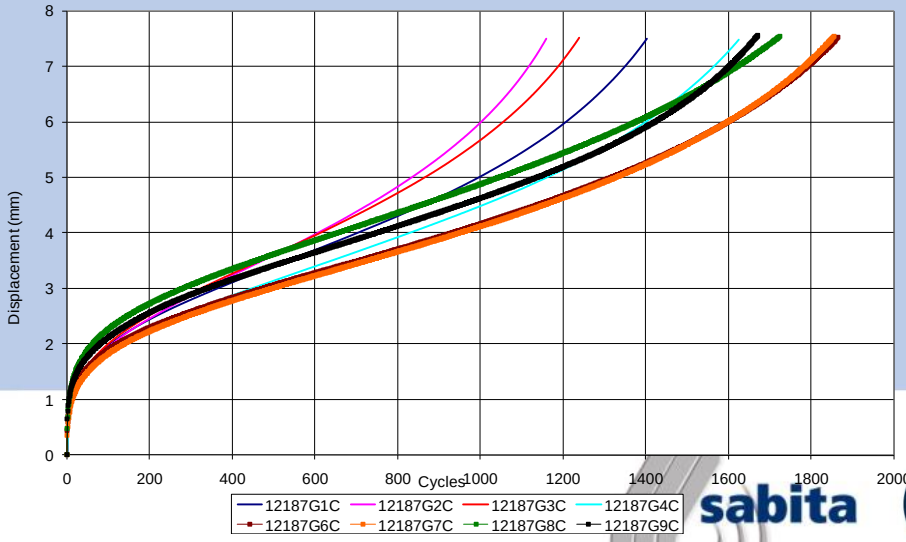
Permanent deformation

- Repeated load simple shear at constant height (RSST-CH, AASHTO T 320)
  - Asphalt mixture performance test (AMPT) repeated load, AASHTO TP 79
  - Hamburg wheel tracking test (HWTT, ASTM D4867M)
- Criteria will be set based on (traffic vs. axial strain/flow number; PG vs. rut depth)



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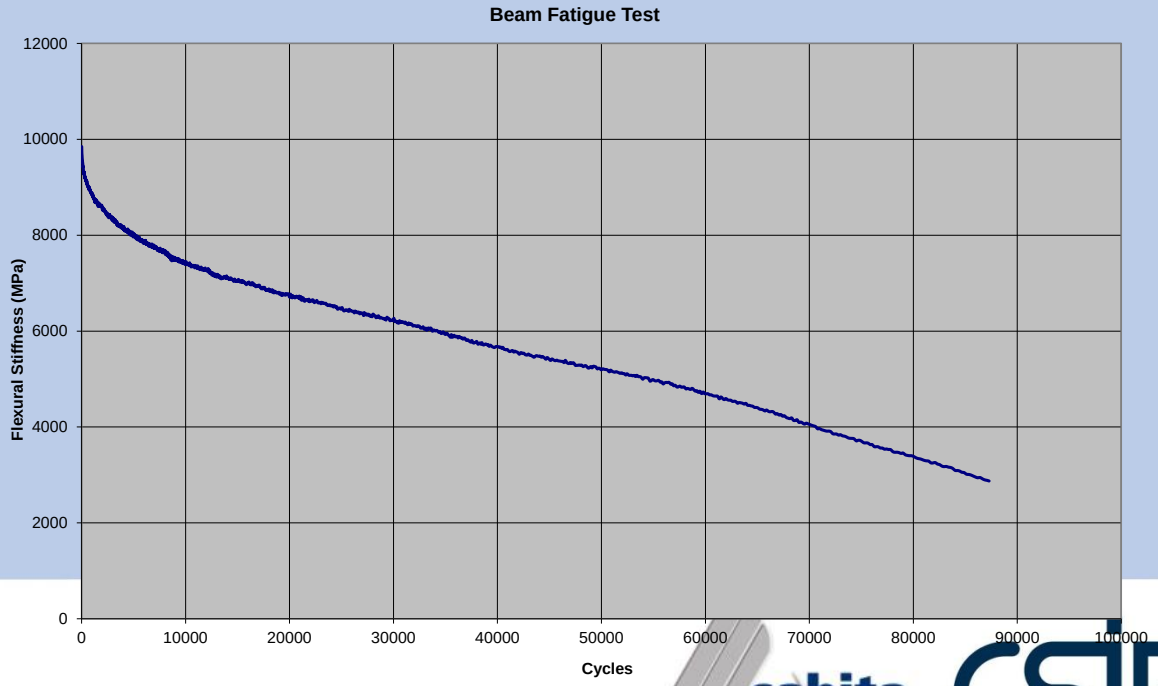
Fatigue

- Flexural four point bending test – AASHTO T 321
  - Beam test at 10Hz, 10 C, to 70% reduction of initial stiffness
- Criteria will be set based on minimum of one million load repetitions at specified strain level



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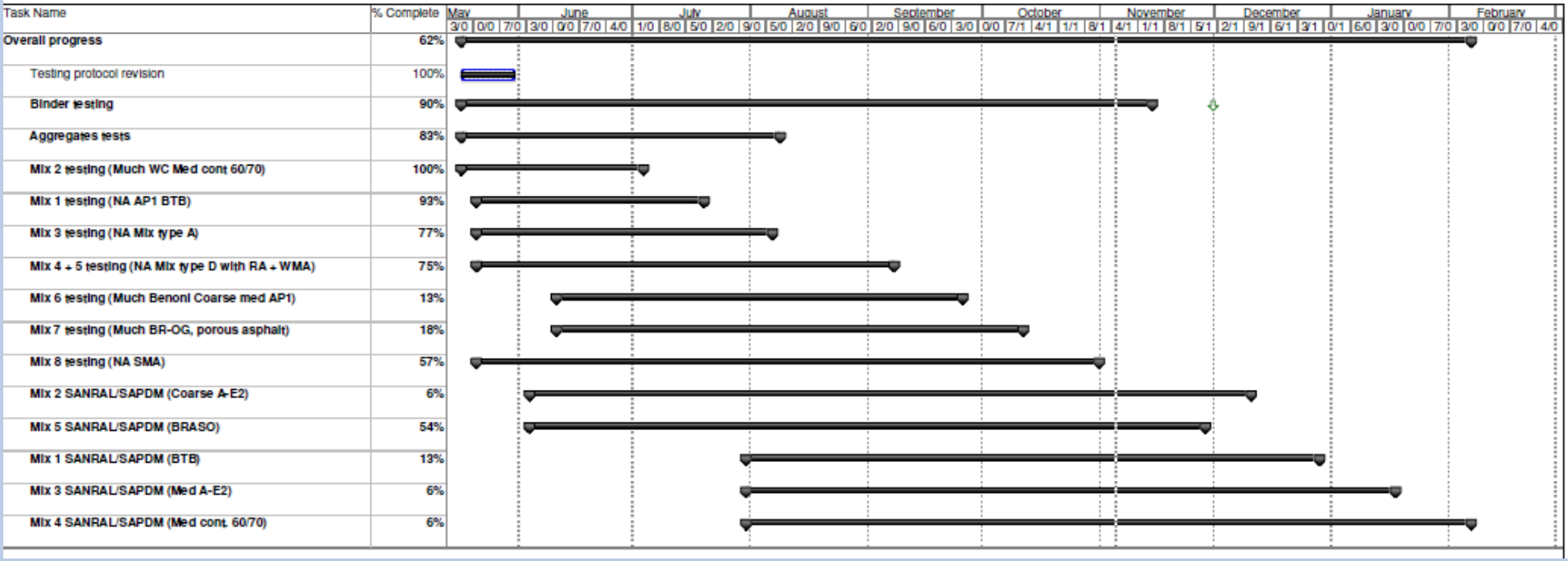
Durability

- Test will be conducted as per ASTM D4867M (Modified Lottman)
- Criteria will be set in terms of the ratio between original and indirect tensile strength retained after conditioning (i.e., TSR)

Summary progress – Lab



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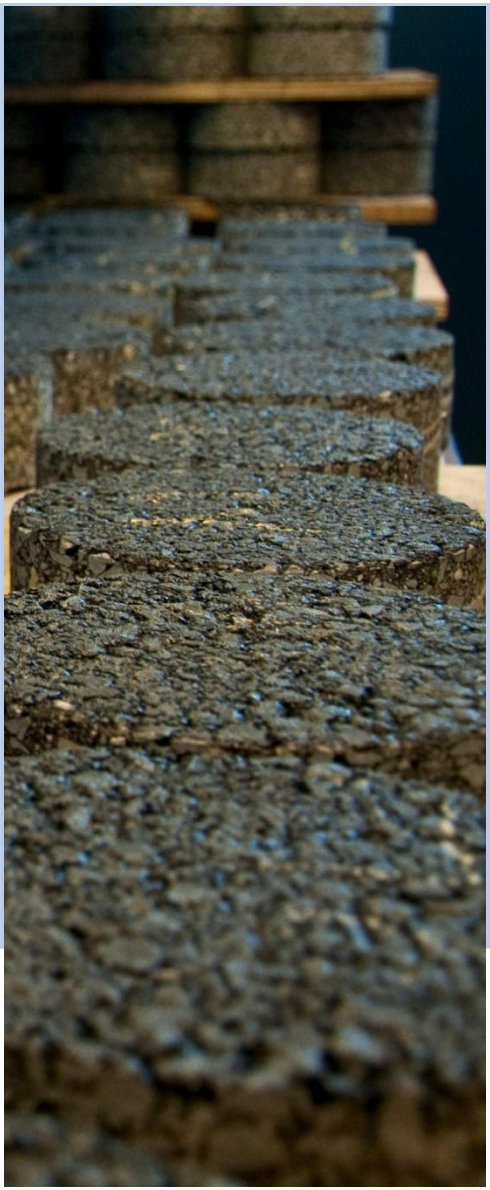
Challenges and way forward



- Fatigue testing – time consuming, may affect final delivery
- Parallel HMA tests – time
  - Permanent deformation tests at additional temperature
  - Laboratory study of confining pressure effect on stiffness and permanent deformation tests (AMPT)
- Dissemination and practice
  - New premix design tool will be proposed
  - SARF programmes
  - Workshops/Conferences

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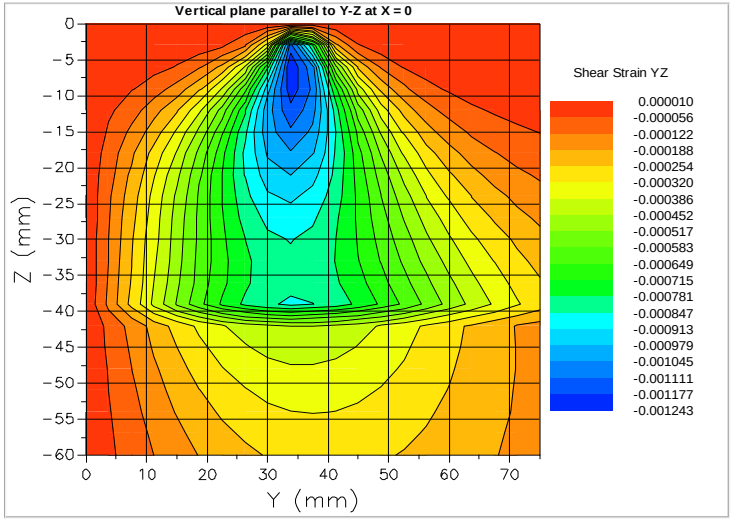
Implementation

Pavement analysis



Structural requirements

Property	value
E* [GPa]	> 5
Fatigue [με to 10^6]	> 300
Perm. def. [ε_p]	< 2%

Tender specification

Property	value
E* [GPa]	> 5
Fatigue [με to 10^6]	> 300
Perm. def. [ε_p]	< 2%
Workability [voids]	< 6%
Durability [TSR]	> 80%

Mix selection

Property	Mix 1	Mix 2	Mix 3
E* [GPa]	14	6	3
Fatigue [με to 10^6]	220	370	280
Perm. def. [ε_p]	0.8 %	1.5 %	4.2 %
Workability [voids]	5.0	4.5	5.2
Durability [TSR]	90	85	75

Thank you..!

Repeated Load Test