South African Asphalt Mix Design Manual

- Progress Update

Prepared for presentation at RPF, 9 May 2012

Johan O'Connell

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Objectives

The objectives of the manual development are:

- Bring asphalt design in SA back in line with international state-of-the-art,
- Complete the migration to performance related design,

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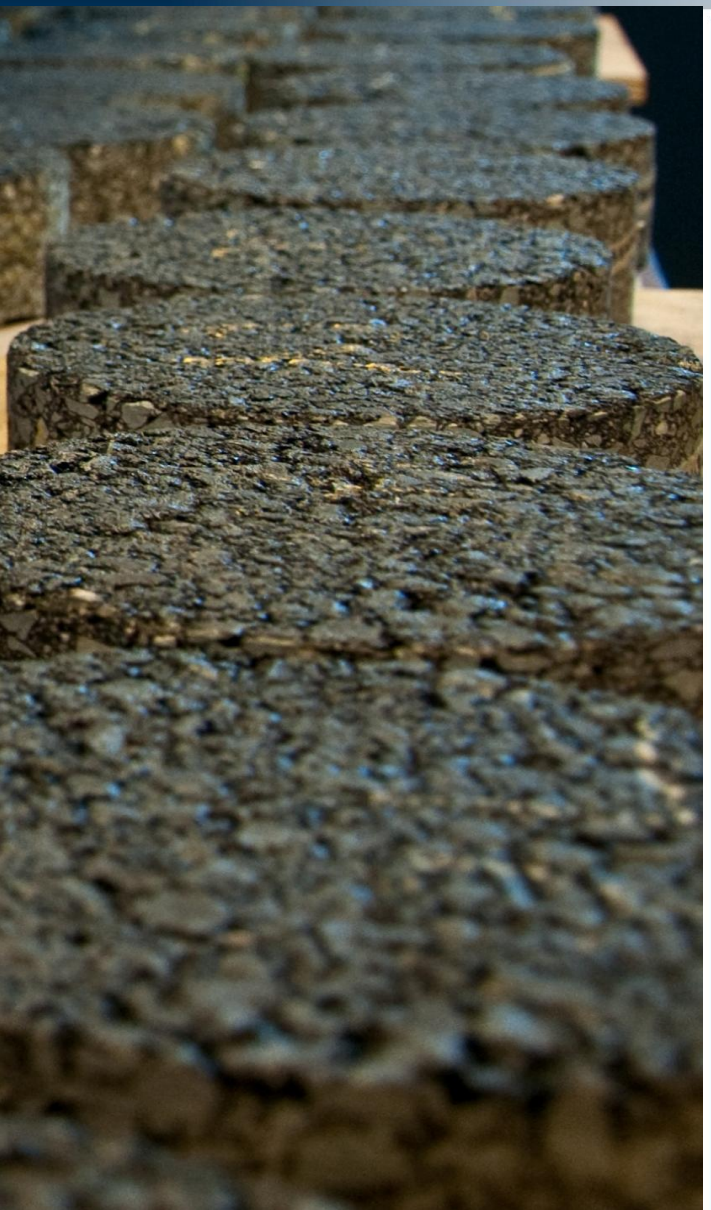
Outline



- Background and progress
- Aims
- State of the art study and key findings
- Outlay of the manual
- Binder Selection – Progress to date
- Laboratory study – Proposed mixes and performance tests

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Background & Progress

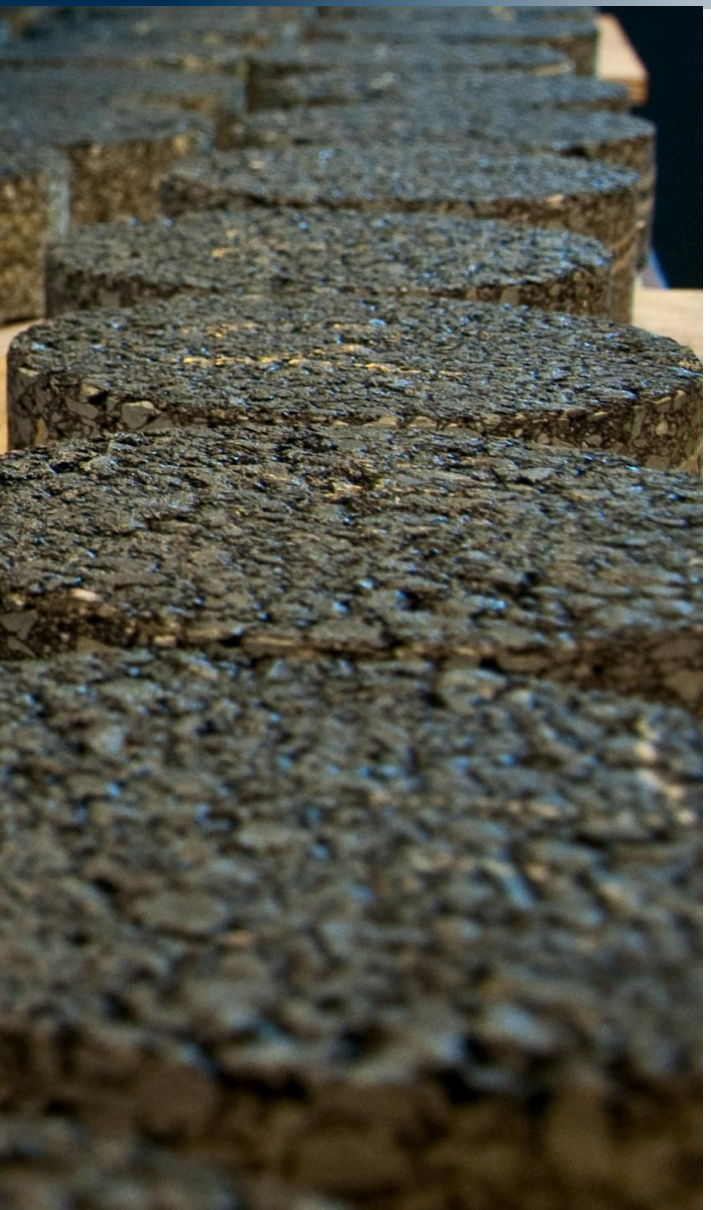
- Drafting of the manual funded by the Southern African Bitumen Association (SABITA),
- Co-funding from CSIR for supporting research,
- Project consists of four phases:

I. Establishment of project management structure,
II. State of the art study,
III. Experimental work and Manual development, and
IV. Dissemination

Aims

- Update the design methods in line with international and local advances in asphalt technology and increasing demands placed on asphalt pavements,
- Include new mix types (e.g. HiMA, WMA), and
- Consolidation and inclusion of previous manual pertaining to asphalt mixes (eg 13 – LAMBS, 17 – porous asphalt, 19 Bitumen rubber)
- Mix design method should have link to structural design methods of revised SAPDM.

State of the art study



- Literature study:
  - Current practice in South Africa,
  - Local developments,
  - International developments.
- Interviews with stakeholders:
  - Producers (and other mix designers),
  - Consultants,
  - Clients,
  - Academics
- Asphalt manual workshop - Midrand Conference Centre, 23 February 2012

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Key Findings

- International trend towards performance related design methods (EU, USA, AUS),
- Performance related design would allow increased reliability and simplification of the mix design and binder selection process,
- Direct link between performance tests and pavement design (SAPDM),
- Typical performance parameters:
  - Workability,
  - Durability,
  - Permanent deformation resistance,
  - Fatigue performance,
  - Stiffness.

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Manual Outlay – 7 Chapters

- Introduction

  History of asphalt mix design in SA, Scope of the manual, Design philosophy

- Mix Type Selection

  Properties of asphalt mixes in SA, Structural and functional requirements

- Binder Selection

  Introduction of PG grade binder selection procedure, in addition to pen grade and modified binders

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Manual Outlay – 7 Chapters….cont.

- Aggregate Selection
  - Performance specs for aggregate selection (esp durability requirements), aggregate packing analysis methods
- Mix Design
  - Based on a comprehensive laboratory study, building on the dataset created as part of the SAPDM project.
  - Criteria set for workability, durability, stiffness, permanent deformation and fatigue performance parameters

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Manual Outlay – 7 Chapters….cont.

- Link to Structural Design

  Temperature models, traffic categories, master curves. Damage prediction. Long life pavements, Airport pavements

- Manufacture and Construction

  Manufacture, Quality Control, Paving Trials, Construction, Tolerances, Trouble Shooting

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Chapter 3: Binder Selection

- Introduction of proposed 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 in binder testing,
- DSR results required to predict stiffness of binder as part of SAPDM,
- Modified and unmodified binders to be assessed using the same specification,
- Project to validate use of PG for SA binders almost complete – only duplicate testing remaining

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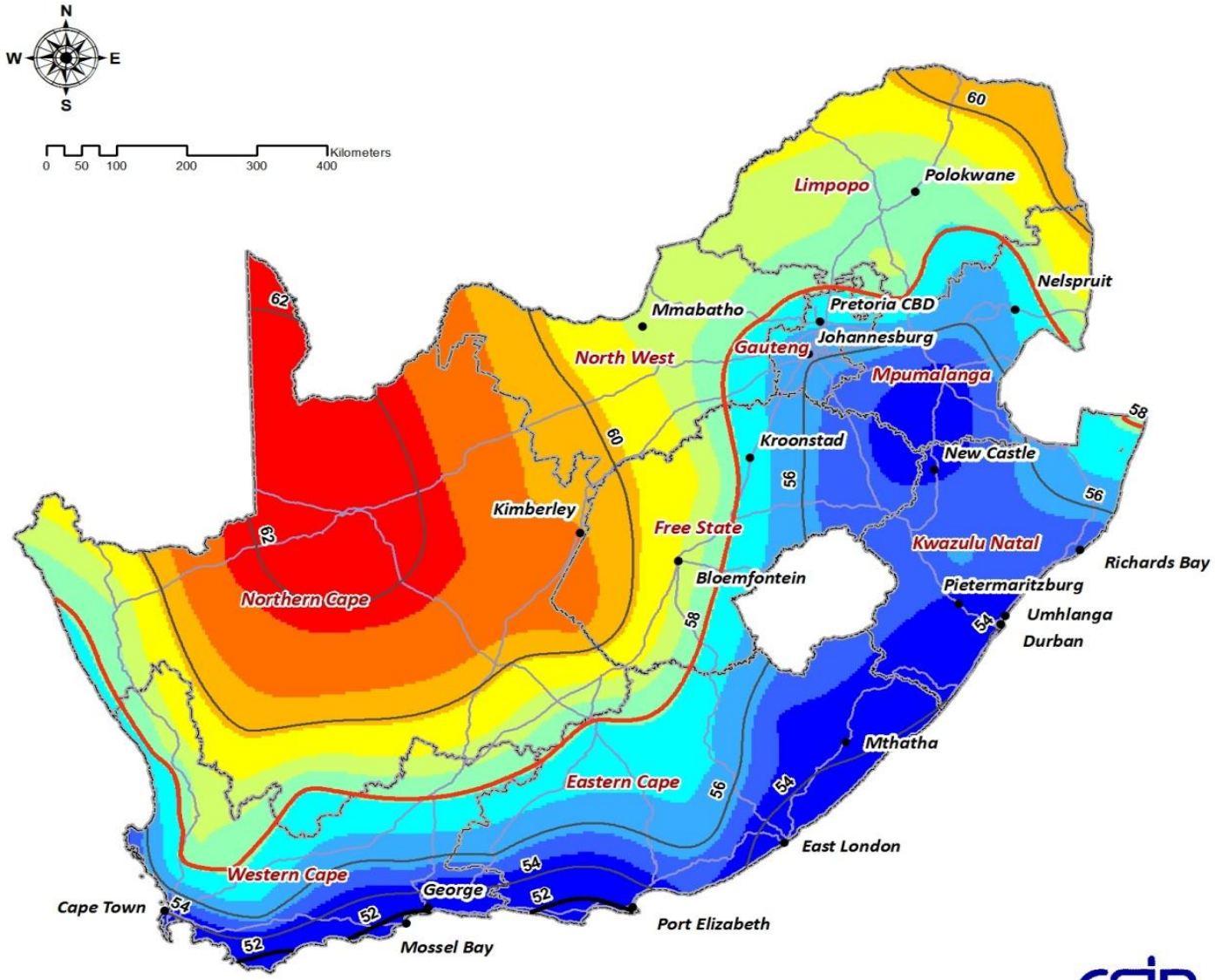
Binder Selection – Temperature Zones



Legend:

- Main Towns/Cities

Contours (warm)

(Temp. - Degrees Celsius)

- 52
- 54
- 56
- 58
- 60
- 62

CLASS

- National
- Provinces

Road Temperature Surface (warm)

(Temp. - Degrees Celsius)

- 50 - 55
- 56 - 56
- 57 - 57
- 58 - 58
- 59 - 59
- 60 - 59
- 60 - 60
- 61 - 61
- 62 - 62
- 63 - 63

Kriging interpolation method applied to available temperature data points.

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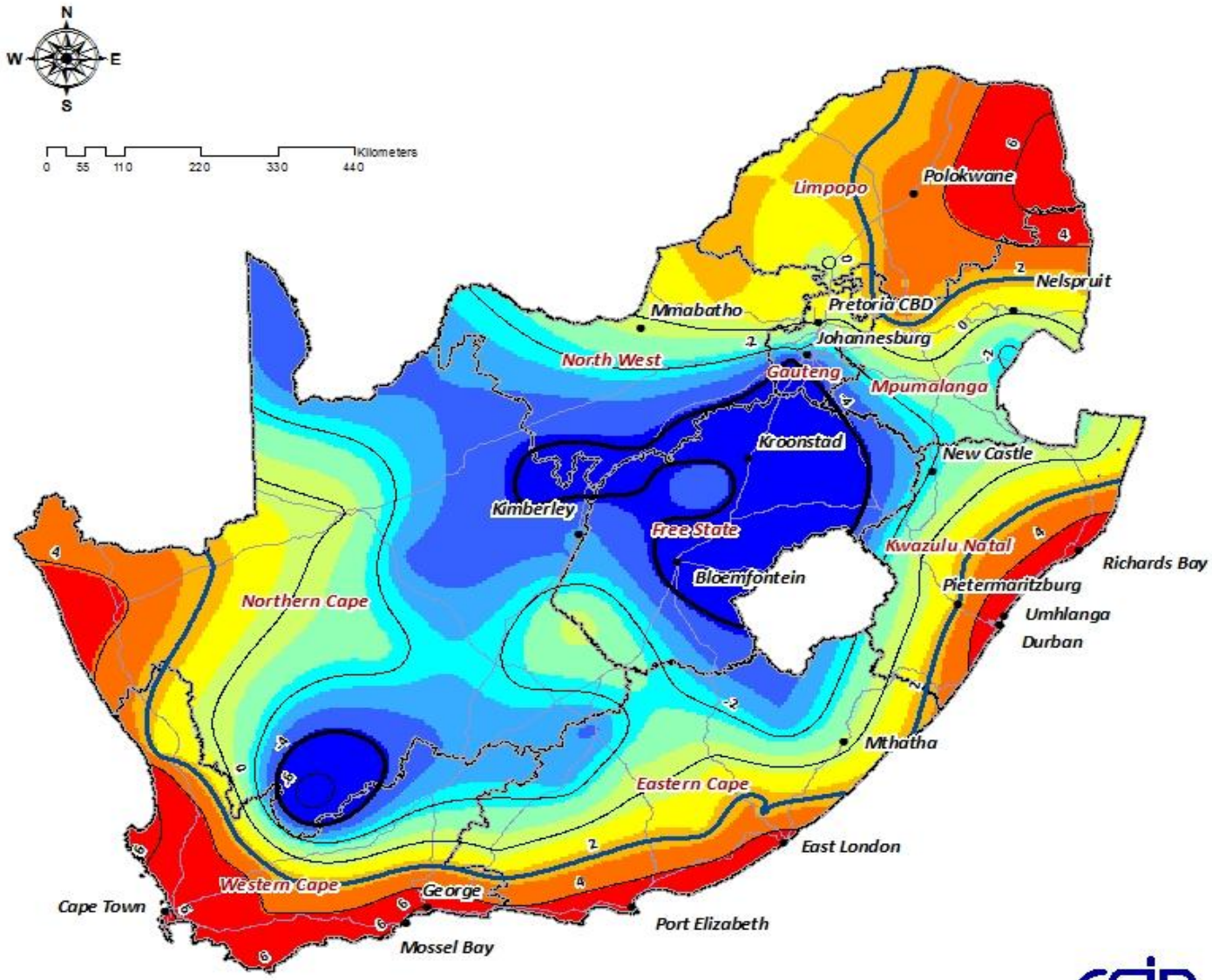
Binder Selection – Temperature Zones



Legend:

- Main Towns/Cities

Contours (Cold)

(Temp. - Degrees Celsius)

-6
-4
-2
0
2
4
6

Roads

National
Provinces

Road Temperature surface (Cold)

(Temp. - Degrees Celsius)

-7 - -4
-3 - -3
-2 - -2
-1 - -2
-1 - -1
0 - 0
1 - 2
3 - 3
4 - 4
5 - 7

Kriging interpolation method applied to available temperature data points.

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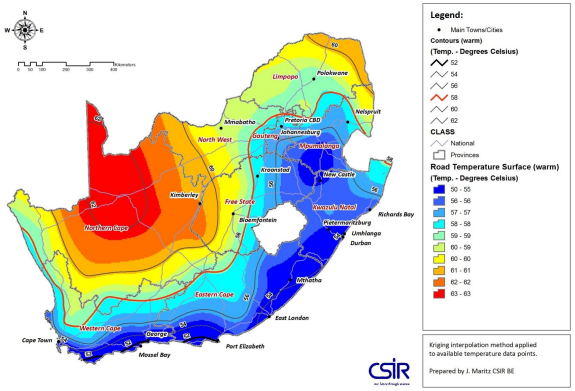
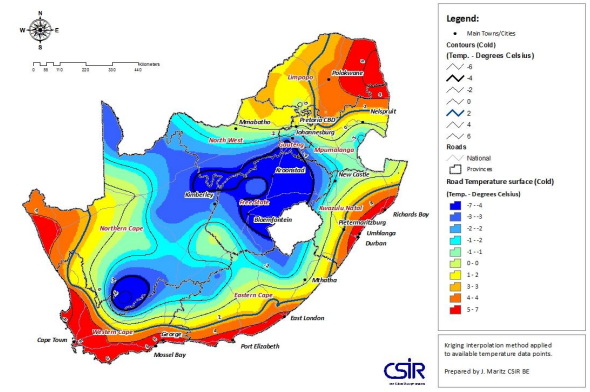
Binder Selection – PG Temperatures





- Superimposing Maximum & Minimum Temp

PG Zone	Intermediate Temperature
PG 58+2	34
PG 64+2	37
PG 64-4	34
PG 64-10	31
PG 58-10	28
PG 58-4	31

- No low temperature cracking is likely to occur in South Africa
- Extreme range for low temp testing for Superpave PG is -4˚C to -10˚. In SA only Sutherland area falls below – 5˚C.
- By foregoing Creep stiffness or direct Tension tests, large cost savings are realised.

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Binder Selection – PG Specification

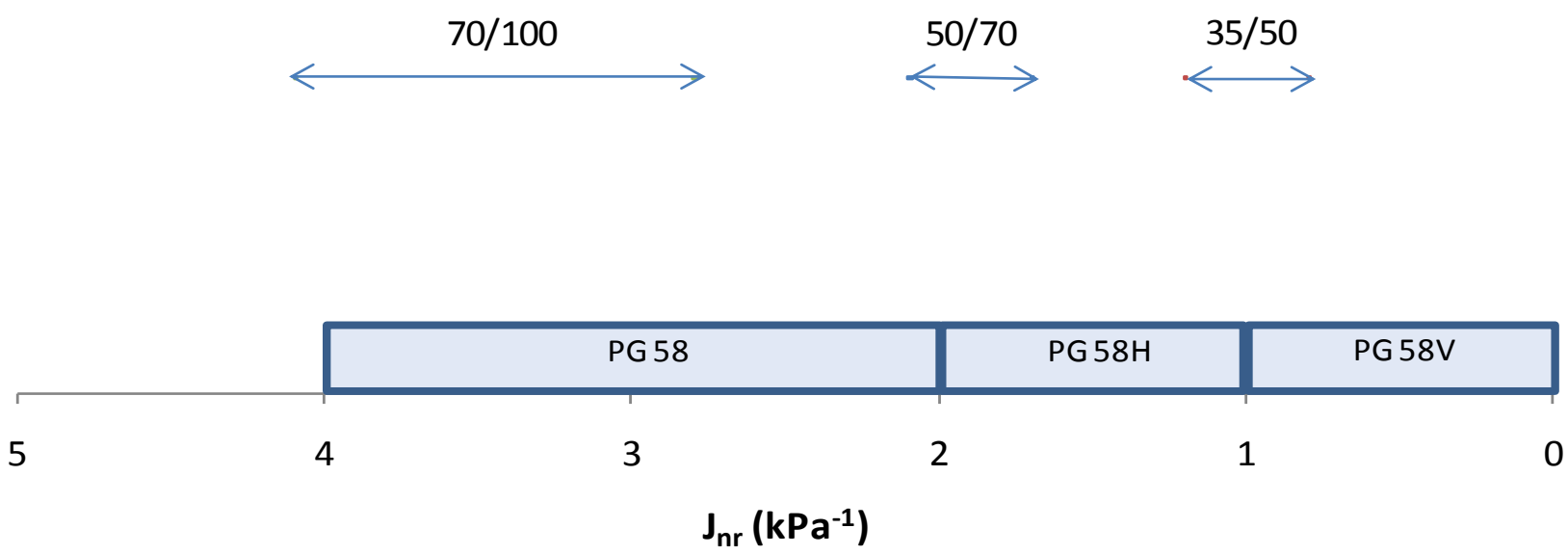
	Proposed Specification				
Binder Class	**58**	**58H**	**58V**	**58Hp**	**58Vp**
Original Binder					
Maximum pavement design temperature (˚C)	≥ 58				
DSR |G*|/sinδ	≥ 1.0 @ 58˚C				
Viscosity Pa.s @ 135˚C	≤ 3.0				
Flash Point (˚C)	≥ 230				
Storage Stability @ 160˚C - Difference in Failure Temperature	N/A			≤ 5.0	
RTFOT Binder					
Mass Change (m/m%)	|0.3| max				
J_{nr} (at σ = 3.2 kPa)	≤ 4.0 kPa^{-1} @ 58 ˚C	≤ 2.0 kPa^{-1} @ 58 ˚C	≤ 1.0 kPa^{-1} @ 58 ˚C	≤ 2.0 kPa^{-1} @ 58 ˚C	≤ 1.0 kPa^{-1} @ 58 ˚C
Percent Recovery at σ = 3.2 kPa	N/A			≥ 25% @ 58 ˚C	≥ 30% @ 58 ˚C
A, VTS viscosity parameters	Report Only				
Rolling Stones Test (% cover)	≥ 80				
PAV Binder - @ 100˚C					
DSR |G*|sinδ	Max 5 000 kPa @ 28 ˚C			Max 6 000 kPa @ 28 ˚C	

Binder Selection – PG Specification

	Proposed Specification					
Binder Class	**64**	**64H**	**64V**	**64Hp**	**64Vp**	**64HIMA**
Original Binder						
Maximum pavement design temperature (˚C)	≥ 64					
DSR |G*|/sinδ	≥ 1.0 @ 64˚C					≥ 10 @ 64˚C
Viscosity Pa.s @ 135˚C	≤ 3.0					
Flash Point (˚C)	≥ 230					
Storage Stability @ 160˚C - Difference in Failure Temperature	N/A			≤ 5.0		
RTFOT Binder						
Mass Change (m/m%)	|0.3| max					
J_{nr} (at σ = 3.2 kPa)	≤ 4.0 kPa^{-1} @ 64 ˚C	≤ 2.0 kPa^{-1} @ 64 ˚C	≤ 1.0 kPa^{-1} @ 64 ˚C	≤ 2.0 kPa^{-1} @ 64 ˚C	≤ 1.0 kPa^{-1} @ 64 ˚C	≤ 0.5 kPa^{-1} @ 64 ˚C
Percent Recovery at σ = 3.2 kPa	N/A			≥ 25% @ 64 ˚C	≥ 30% @ 64 ˚C	N/A
A, VTS viscosity parameters	Report Only					
Rolling Stones Test (% cover)	≥ 80					
PAV Binder - @ 100˚C						
DSR |G*|sinδ	Max 5 000 kPa @ 28 ˚C			Max 6 000 kPa @ 28 ˚C		Max 5 000 kPa @ 34 ˚C

Binder Selection – Evaluation of SA Binders

J_{NR} Equivalence of penetration grade binders evaluated (PG 58)



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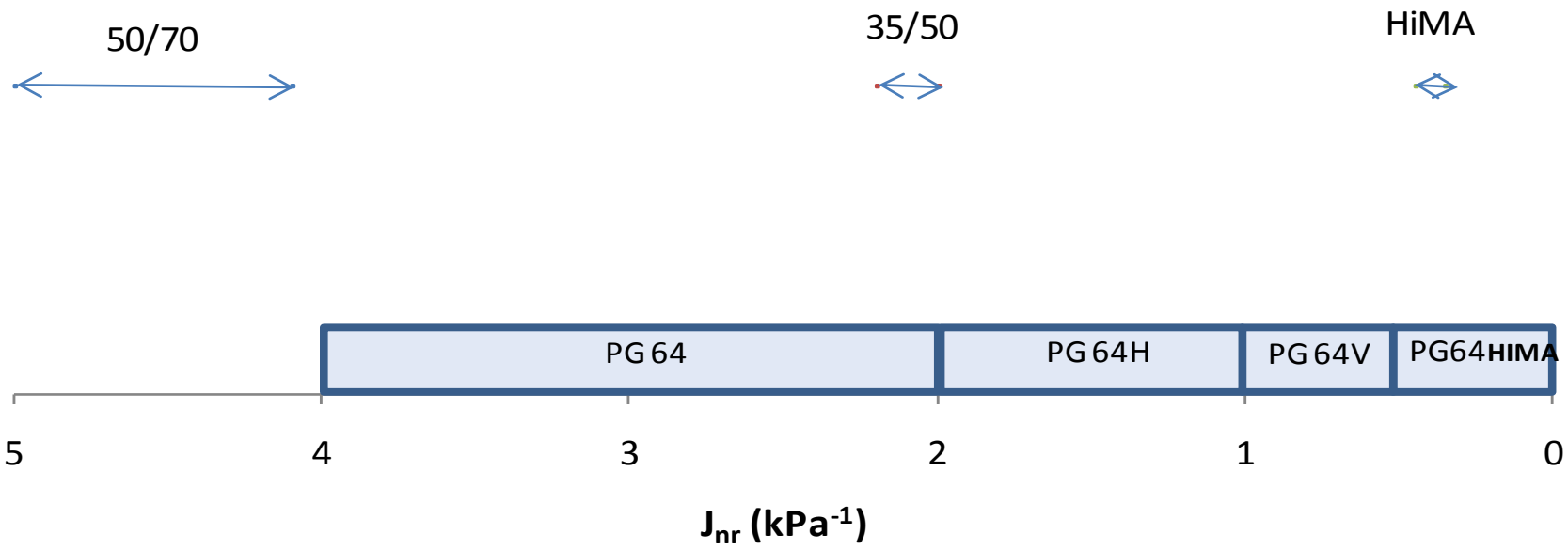
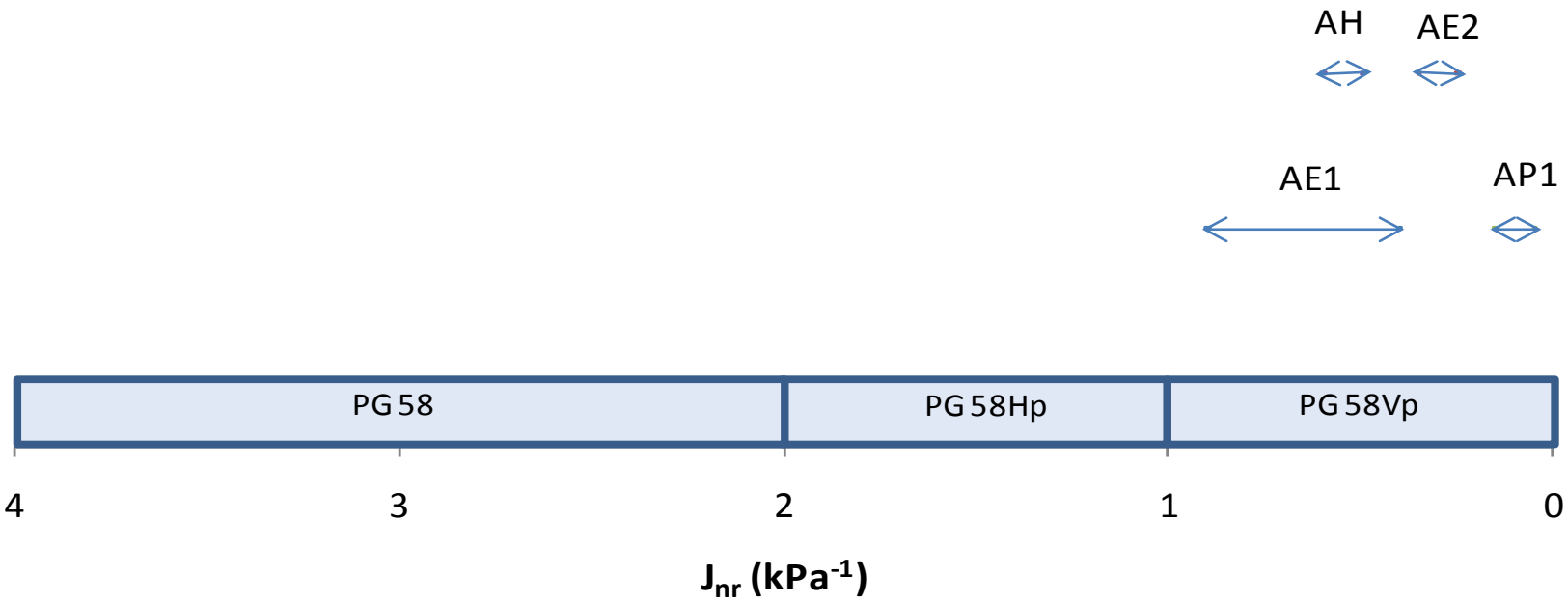


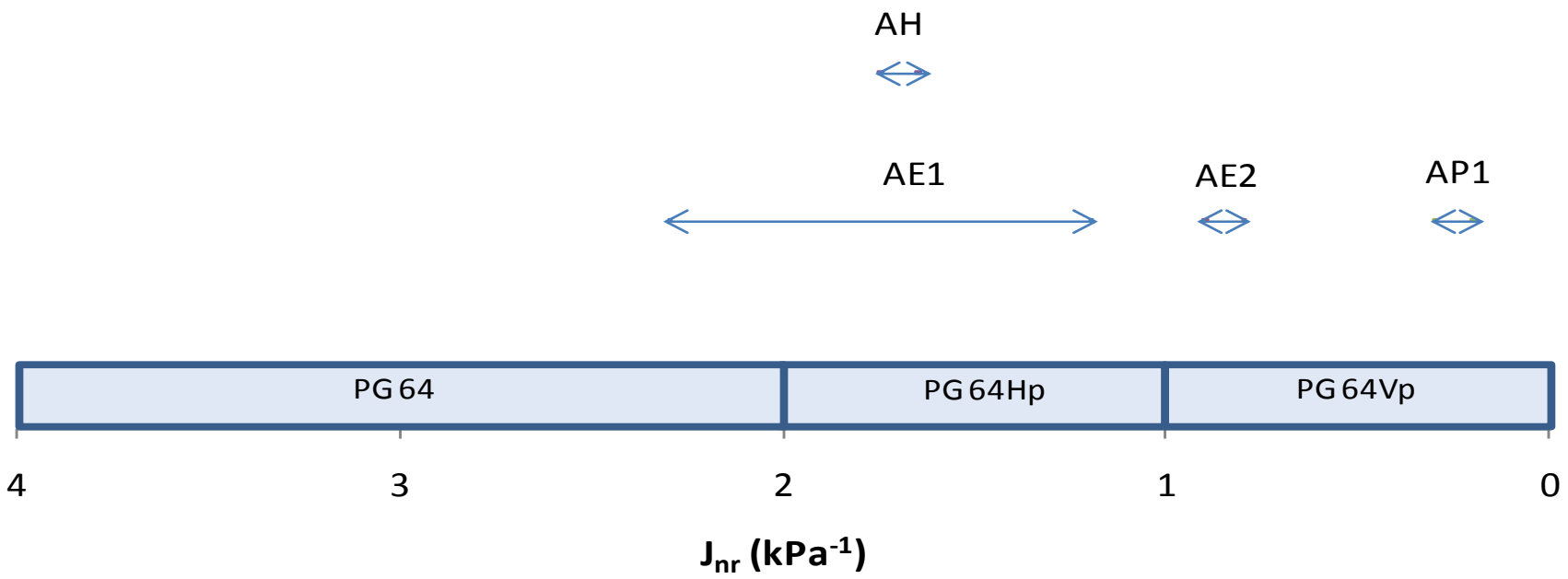
Binder Selection – Evaluation of SA Binders

J_{NR} Equivalence of modified binders evaluated (PG 58)



Vision for the asphalt manual: binder testing

J_{NR} Equivalence of modified binders evaluated (PG 64)



Mix Design – Laboratory Study

In addition to the 5 SAPDM (GFIP) mixes:

1. AP1 BTB – National Asphalt (Durban)
2. Medium continuous + 60/70 – Much (CT)
3. Durban std mix Type A – National Asphalt
4. Durban std mix Type D + recycled asphalt – National Asphalt (Durban)
5. Durban std mix Type D + warm mix additive – National Asphalt (Durban)
6. Coarse continuous AP1 – Much (Benoni)
7. Porous Asphalt with bitumen rubber
8. SMA - National Asphalt (Durban

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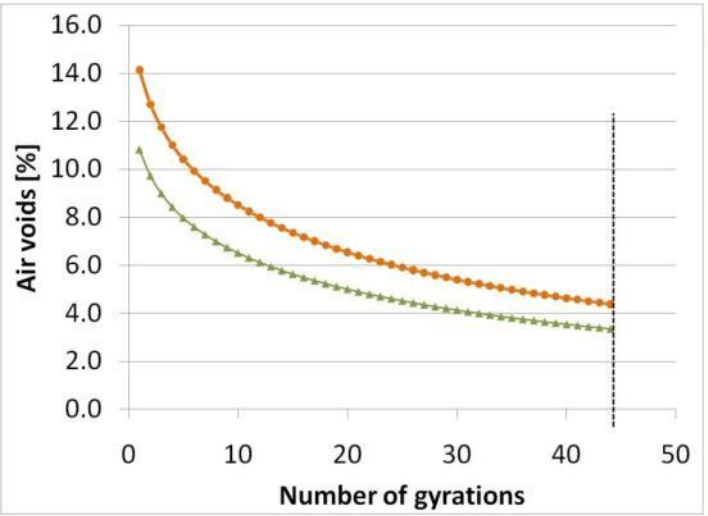
Performance testing: Workability



- SUPERPAVE gyratory compactor – ASTM D2013-98 (note: minimum specimen height of 175 mm required)
- Compact to a set number of gyrations to meet compaction effort under rollers in the field
- Mix design requirement: maximum air void content at specified number of gyrations
- Asphalt producers will be involved in this study to relate workability in the gyratory compactor to compactability in the field

Performance testing: Stiffness

- Will be derived from the dynamic modulus test – AASHTO TP 62
- Mix design requirement: minimum modulus at fixed combination of load frequency and temperature
- Equipment can be used for master curve development → input into SAPDM
- AMPT equipment for dynamic modulus test can also be used for deformation test

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Performance testing: Permanent deformation

- Suitable test still to be selected – 3 tests to be done
- RSST-CH as benchmark, but equipment too expensive for use in mix design
- AMPT test (simple performance test) → input for SAPDM models, ITS & E* can also be determined
- (Hamburg) wheel tracking test → No link with SAPDM models, also gives indication of durability
- Mix design requirement: level of permanent deformation after set number of load repetitions at design temperature

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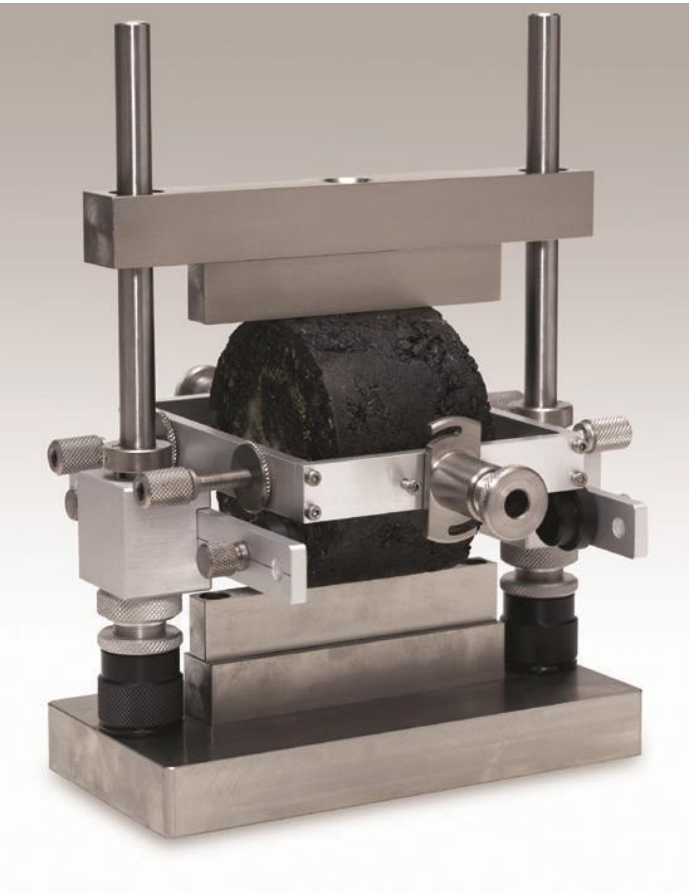
Performance testing: Durability



- Modified Lottman: TSR – ASTM D4867
- Possible alternative: stripping inflection point HWTT

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Performance testing: Fatigue

- Flexural four point bending test – AASHTO T 321
- Can also be used to determine dynamic modulus → mix design parameter
- Fatigue results → input SAPDM models
- Mix design requirement: minimum strain level to 10^6 load repetitions at set frequency and temperature

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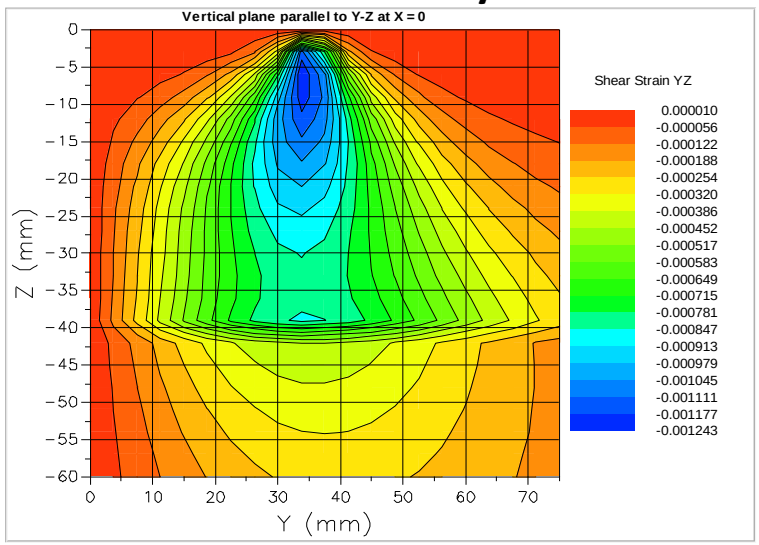
Vision for implementation

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!