SA PG Binder Specifications

Road Pavement Forum

May 2017 Durban

Steph Bredenhann

Specifications and Rheology

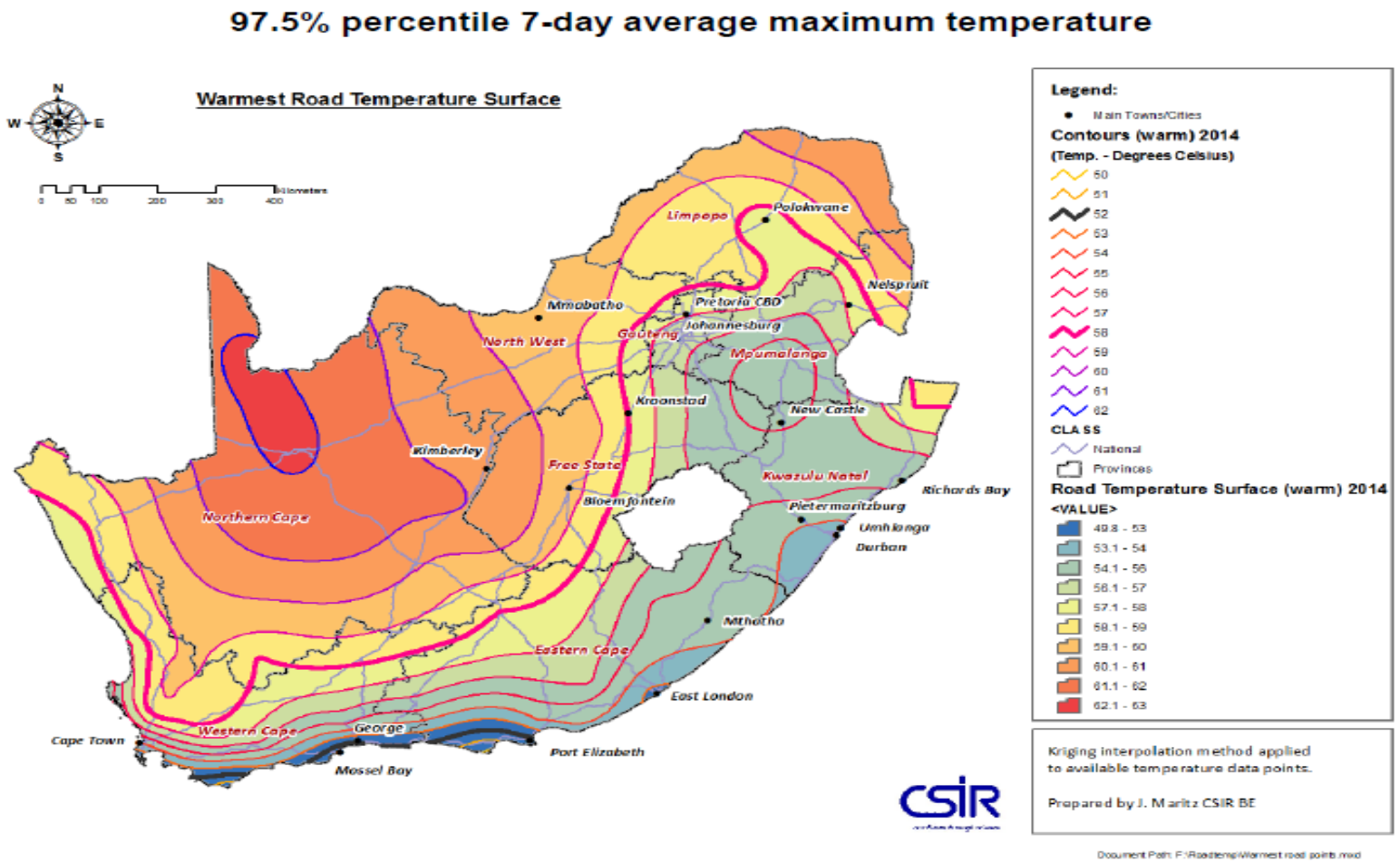
Overview

- Specification framework
  - Unaged binder
  - RTFO aged binder – Short-term aged binder (STA)
  - RTFO and PAV aged binder - Long-term aged binder (LTA)
- Research
- Quality control
- Finger printing
- Implementation plan
- SA binder production
- Example results

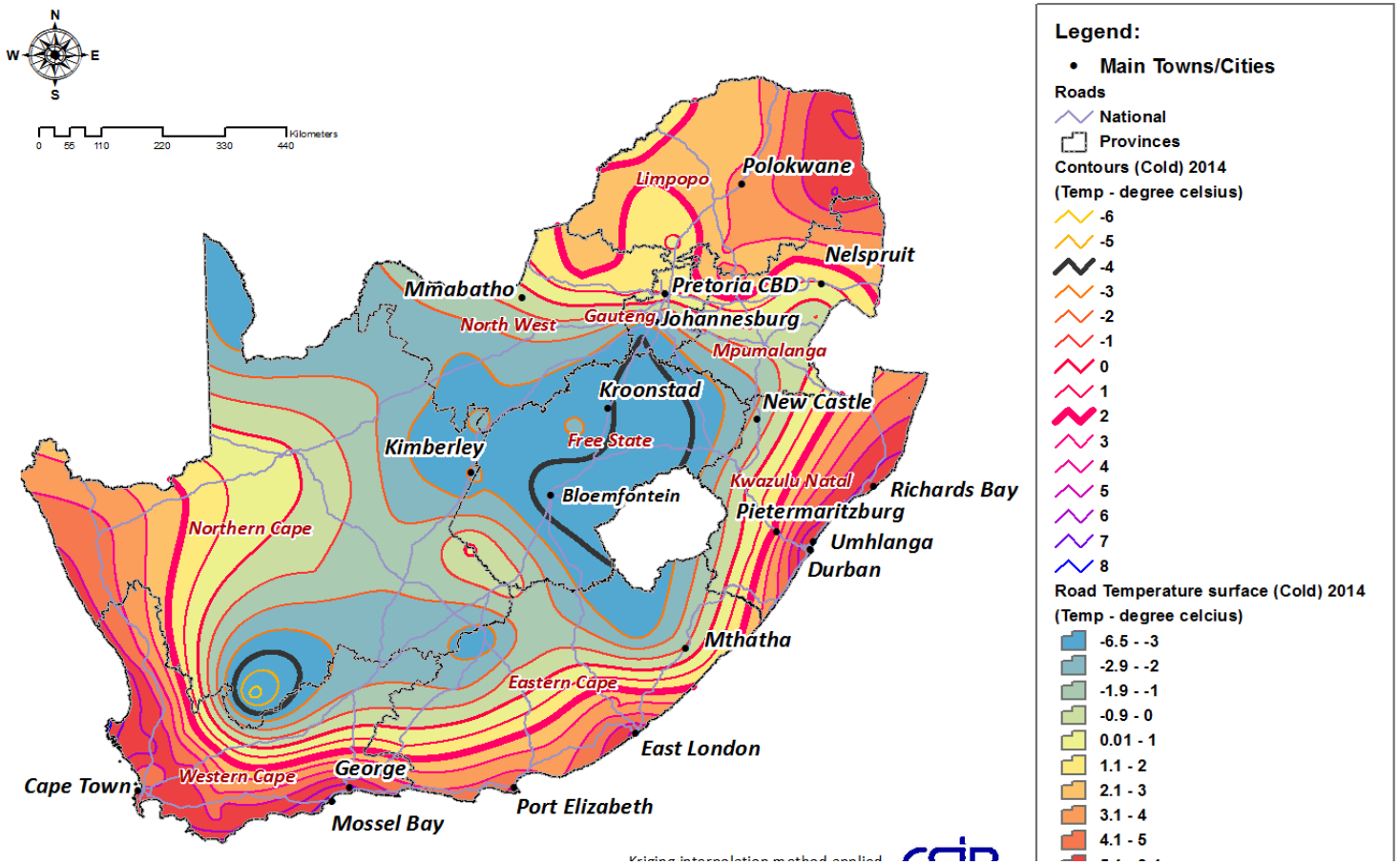
The SA Performance Grade Binder Specification PG58-22

Test Property	Note	South African Performance Grades												Test Method
		58S-22	58H-22	58V-22	58E-22	64S-16	64H-16	64V-16	64E-16	70S-10	70H-10	70V-10	70E-10	
Max pavement design temperature (°C)	1.1	58	58	58	58	64	64	64	64	70	70	70	70	
Minimum grading temperature (°C)	1.1	-22	-22	-22	-22	-16	-16	-16	-16	-10	-10	-10	-10	
G* and δ at [(T_{max} + T_{min})/2+4]°C	1.11	Compulsory report only – see detail description of report only item												ASTM D7175
G*/sinδ @10rad/s (kPa) @ T = T_{max} Report G* and δ separately	1.3	≥ 1.0												ASTM D7175
Viscosity at 165°C (Pa.s) ≥ 30 sec^{-1}	1.4	≤ 0.9												ASTM D4402
Storage Stability at 180°C (% diff in G* at T_{max})	1.5	≤ 10												ASTM D7175
Flash Point (°C)		≥ 230												ASTM D92b
	1.6	After RTFO Ageing												ASTM D2872 / TG1 MB3
G* and δ at [(T_{max} + T_{min})/2+4]°C,	1.11	Compulsory report only – see detail description of report only item												ASTM D7175
Mass Change (% m/m)		≤ 0.3	≤ 1.0			≤ 0.3	≤ 1.0			≤ 0.3	≤ 1.0			ASTM D2872 / TG1 MB3
J_{nr} at T_{max} (kPa^{-1})		≤ 4.5	≤ 2.0	≤ 1.0	≤ 0.5	≤ 4.5	≤ 2.0	≤ 1.0	≤ 0.5	≤ 4.5	≤ 2.0	≤ 1.0	≤ 0.5	ASTM D7405
Ageing ratio [G^*_{RTFO} / $G^*_{Original}$]	1.9	≤ 3.0												ASTM D7175
		After RTFO plus PAV Ageing												ASTM D6521
G* and δ at [(T_{max} + T_{min})/2+4]°C,	1.11	Compulsory report only – see detail description of report only item												ASTM D7175
Maximum creep stiffness tested at temperature (T_{min} + 10°C), MPa, [S (60s) ≤ 300 MPa]		-12 °C				-6 °C				0 °C				ASTM D6648
Minimum m-value tested at temperature (T_{min} + 10°C), [m (60s) ≥ 0.300]		-12 °C				-6 °C				0 °C				
ΔT_c(°C) = $T_{c,S}$ – $T_{c,m}$	1.8	≥ -5												ASTM D7643
Ageing ratio [G^*_{PAV} / $G^*_{Original}$]	1.9	≤ 6.0												ASTM D7175

Climatic Regions – Maximum Temperatures



Climatic Regions – Minimum Temperatures



Traffic Definition

Design traffic (million E80)	Traffic Speed (km/h)			Asphalt mix design level
	< 20	20 - 80	>80	
< 0.3	S	S	S	IA
0.3 - 3	H	S	S	IB
> 3 - 10	V	H	S	II
> 10 - 30	E	V	H	
> 30	E	E	V	III

S = standard conditions, H = heavy conditions, V = very heavy conditions, E = extreme conditions

Specification for Unaged Binder

- $G^*/\sin\delta \geq 1.0$ at 10 rad/sec and $T = T_{max}$, report G^* and δ separately
  - Originally meant for S traffic class only to link to Superpave
  - Upon industry request it was included for all binders and traffic classes for QA purposes.
- Viscosity ≤ 0.9 @ 165 °C and 30 sec^{-1} for pumpability
- Storage stability ≤ 10 @ 180 °C expressed as % diff in G^* at T_{max}
  - Determined from top and bottom of tank.
  - Calculate as $[G^*_{HIGH} - G^*_{LOW}] / G^*_{HIGH}$ (from top/bottom sample). The G^* is measured at T_{high}
- Flash point for safety ≥ 230 °C, directly from SANS

Specification for RTFO Aged Binder (STA)

- Mass change (% m/m), as per SANS
  - ≤ 0.3 for S-class
  - ≤ 1.0 for all other traffic classes
- J_{NR} @ T = T_{max}
  - ≤ 4.5 for S-class
  - ≤ 2.0 for H-class
  - ≤ 1.0 for V-class
  - ≤ 0.5 for E-class
- Ageing ratio (G^*_{RTFO}/G^*_{unaged}) ≤ 3
  - G* and δ measured @ 10 rad/sec
  - Use 8 mm spindle unless G* < 100 kPa, then use 25 mm spindle

Specification for RTFO and PAV Aged Binder (LTA)

- Maximum creep stiffness tested at temperature (T_{min} + 10 °C)
  - S(60 sec) ≤ 300 MPa
- Minimum m-value tested at temperature (T_{min} + 10 °C)
  - m(60 sec) ≥ 0.3
- $\Delta T_c = T_{c,S} - T_{c,m}$ (°C)
  - Critical temperature for S, $T_{c,S}$ where S(60) = 300 MPa
  - Critical temperature for m, $T_{c,m}$ where m(60) = 0.3
  - T_c values must be obtained through interpolation
- Ageing ratio ($G^*_{RTFO+PAV}/G^*_{unaged}$) ≤ 6

Data for Record Only

- Tests done at intermediate temperature (IT), $T_{IT} = (T_{max}+T_{min})/2 + 4$
- Combine with BBR data (converted to G* and δ)
- Draw mater curves – one isotherm DSR plus BBR (all isotherms)
- Calculate G-R, etc
- Frequencies as per table

Log basis	Linear basis (rad/sec)	Linear basis (Hz)
-0.6	0.251	0.0400
-0.4	0.398	0.0634
-0.2	0.631	0.100
-0.0	1.00	0.159
+0.2	1.58	0.252
+0.4	2.51	0.400
+0.6	3.98	0.634
+0.8	6.31	1.00
+1.0	10.0	1.59
+1.2	15.8	2.52
+1.4	25.1	4.00

Research

- Five (5) Masters students at Stellenbosch University
  - Bitumen for asphalt
    - ✓ Study ageing characteristics
      - Laboratory
      - From recovered field samples
  - Bitumen for surfacing seals (as above)
  - Fatigue performance (PG vs 4-pt beam test)
  - Storage stability
  - Quality control measures
- Needed to fine-tune boundaries

Test frequency

- TG1 example
- Working on test frequency regime for PG specification
  - Considering PAV (long term ageing)
  - Time constraints

Table 19: Test frequencies for hot polymer modified binders				
Property	**Manufacturer**	**Haulier**	**Site storage**	**Sprayer**
Before ageing				
Softening Point	Every batch	Every load	Every day	Every load
Elastic recovery @ 15°C	Every batch			Every 5th load
Dynamic Viscosity @ 165°C	Every batch			Every 5th load
Storage stability @ 160°C[1]	Every 10th batch			
Flash Point	Once, at start of project			
After ageing (RTFOT)				
Mass change	Every 10th batch			Every 10th load
Difference in Softening Point	Every 10th batch			Every 10th load
Elastic recovery @ 15°C	Every 10th batch			Every 10th load
Dynamic Viscosity @ 165°C[2]	Every 10th batch			

Site Quality Control and Acceptance

- DSR equipment too expensive for site
  - BUT, newer models (low end) are affordable
  - AND, new viscometers based on DSR
- Still use "conventional" tests
  - Ring & Ball
  - Viscosity
- Research effort during two years of parallel testing to establish norms
- Final decision to be made after two years

Bitumen Finger Printing

- Require assistance from industry
- Data base of all current bitumens produced
  - In terms of PG specification
- Plus additional testing for reference purposes
  - Temperature sweeps for Tg definition
  - Frequency sweeps for full master curves
- Model choice

Implementation Plan

- Introduction to industry on 25th January 2016
- Workshops to inform industry March 2016
  - 15th in Johannesburg
  - 16th in Cape Town
  - 17th in Durban
  - 18th in Port Elizabeth
- Bitumen Rheology Masterclass
  - 21-23 June 2016 in Pretoria
  - International experts
  - **Followed up April 2017 in Cape Town**
- Two-year parallel implementation
  - Include data analyses and research

Final Implementation

- Final implementation
  - SANS draft with SABS

The end!