Performance-grade Binder In South Africa

- Implementation and Final Specification -

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ROAD PAVEMENT FORUM

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Objectives

- Products in SA
- Specifications
- Implementation
- PG Specification vs Project Specification

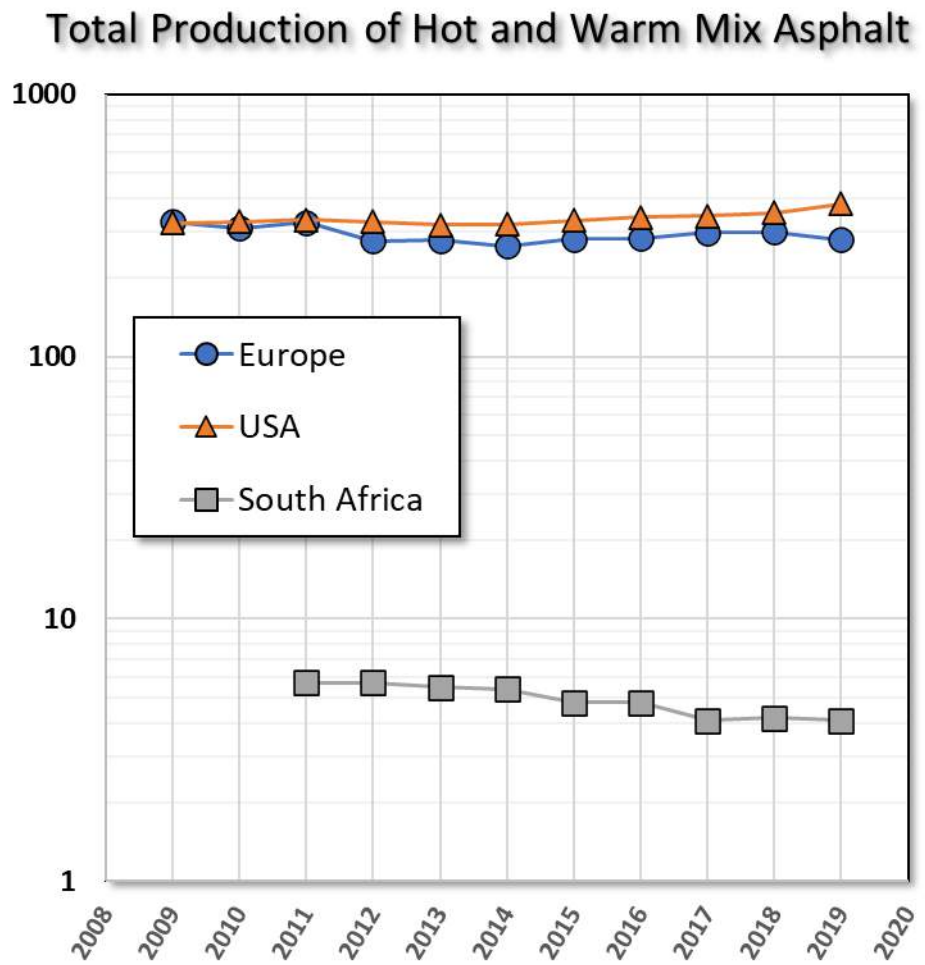
Bitumen production in South Africa

- In South Africa most bitumen used in road construction is processed at oil refineries in Cape Town, Sasolburg and Durban, or
- is imported from other sources.

Astron refinery	Astron Energy – acquired former Chevron South Africa refinery in Cape Town	https://www.astronenergy.co.za/company-overview/
Natref	A joint venture between Sasol mining (Pty) Ltd and Total South Africa (Pty) Ltd	https://www.total.co.za/discover-total/total-south-africa/natref-refinery
SAPref	Joint venture - Shell Refining SA and BP Southern Africa	https://www.sapref.com/who-we-are
Engen refinery	Joint venture between Petronas, Phembani and a Phembani led consortia	https://www.engen.co.za/about/manufacturing

HMA and WMA Production

- Production of materials in South Africa tend to vary between about 4 and 6 million tons per year
- Fraction of production in Europe and USA
- HMA/WMA Production
  - About 30 to 40 companies



https://eapa.org/wp-content/uploads/2020/12/Asphalt-in-figures_2019.pdf

Modification in common use

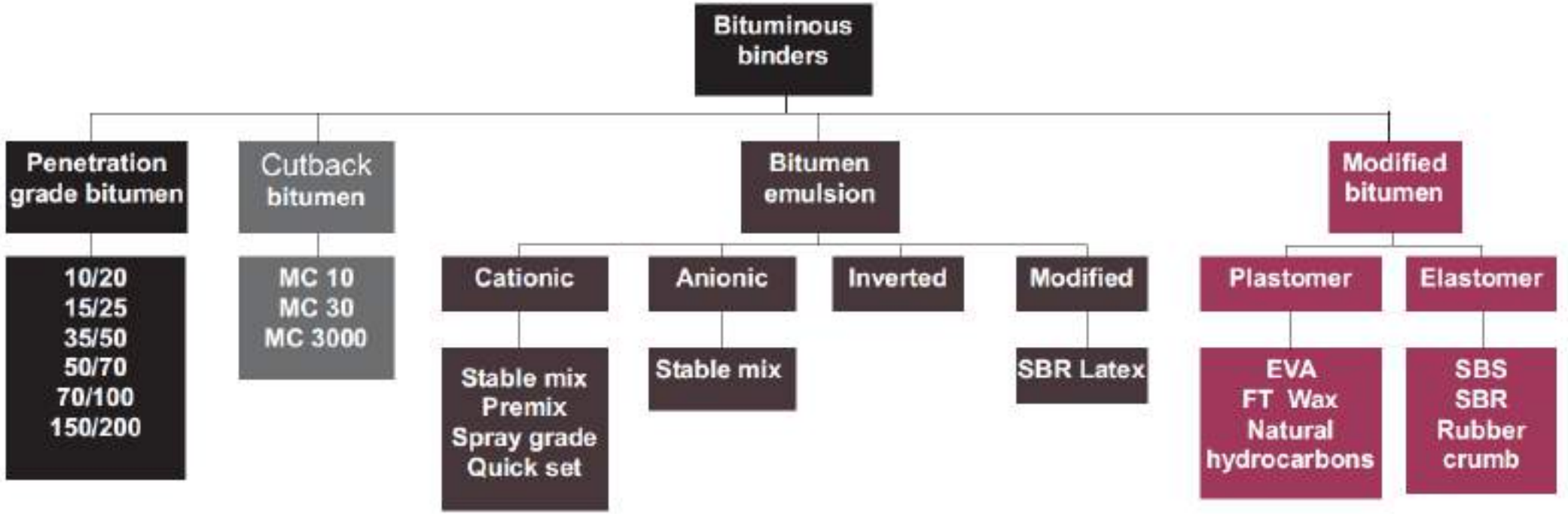
- Table from SABITA Manual 2

Modifier type		Varieties
Polymers	Elastomers	Styrene-butadiene-styrene (SBS)
		Styrene-butadiene-rubber (SBR) latex
		Reactive Elastomeric Terpolymer (RET)
		Rubber Crumb
	Plastomers	Ethylene-vinyl-acetate (EVA)
Hydrocarbon substances	Aliphatic synthetic wax	Fischer-Tropsch (FT) wax
	Natural occurring hydrocarbons	Gilsonite
		Durasphalt

SABITA – formally Southern Africa Bitumen and Tar Association, changed name to Southern Africa Bitumen Association in mid-1990s

Available grades and types of bituminous binders

- SABITA Manual 2 – page 52



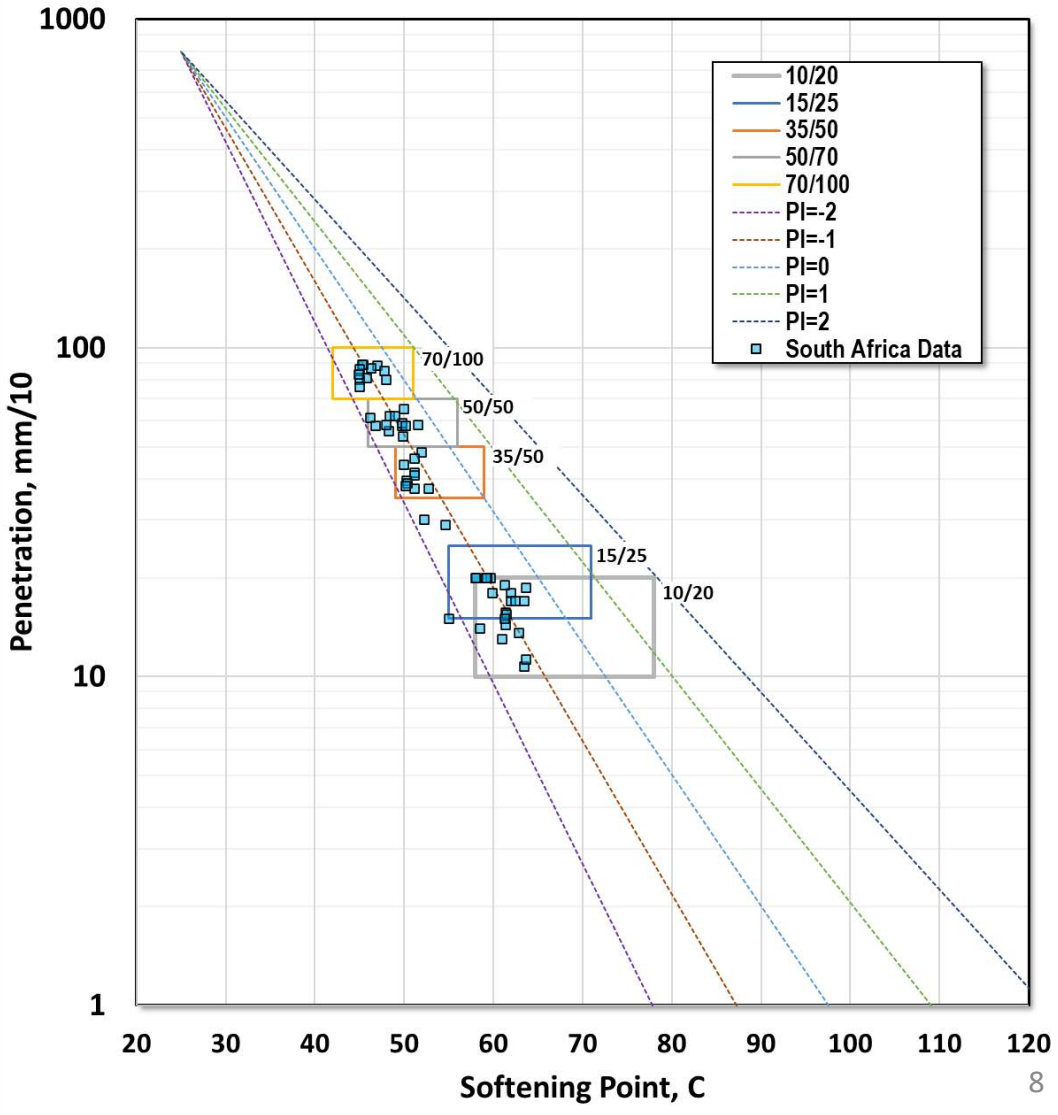
Specifications

- Older methods based on
  - PEN and Softening Point
- Now we have developments of Superpave specifications being implemented
- Standards
  - SANS BT1 for conventional bitumen
  - SATS 3208 (SANS BT10) for PG
  - Useful to review SABITA documents
  - COTO
  - Project specifications

Some (unmodified) Bitumen Results

- Old specification based upon Penetration and Ring and Ball Softening Point

SANS 4001:BT1			
Pen		SP	
10	20	58	78
15	25	55	71
35	50	49	59
50	70	46	56
70	100	42	51



Superpave Implementation

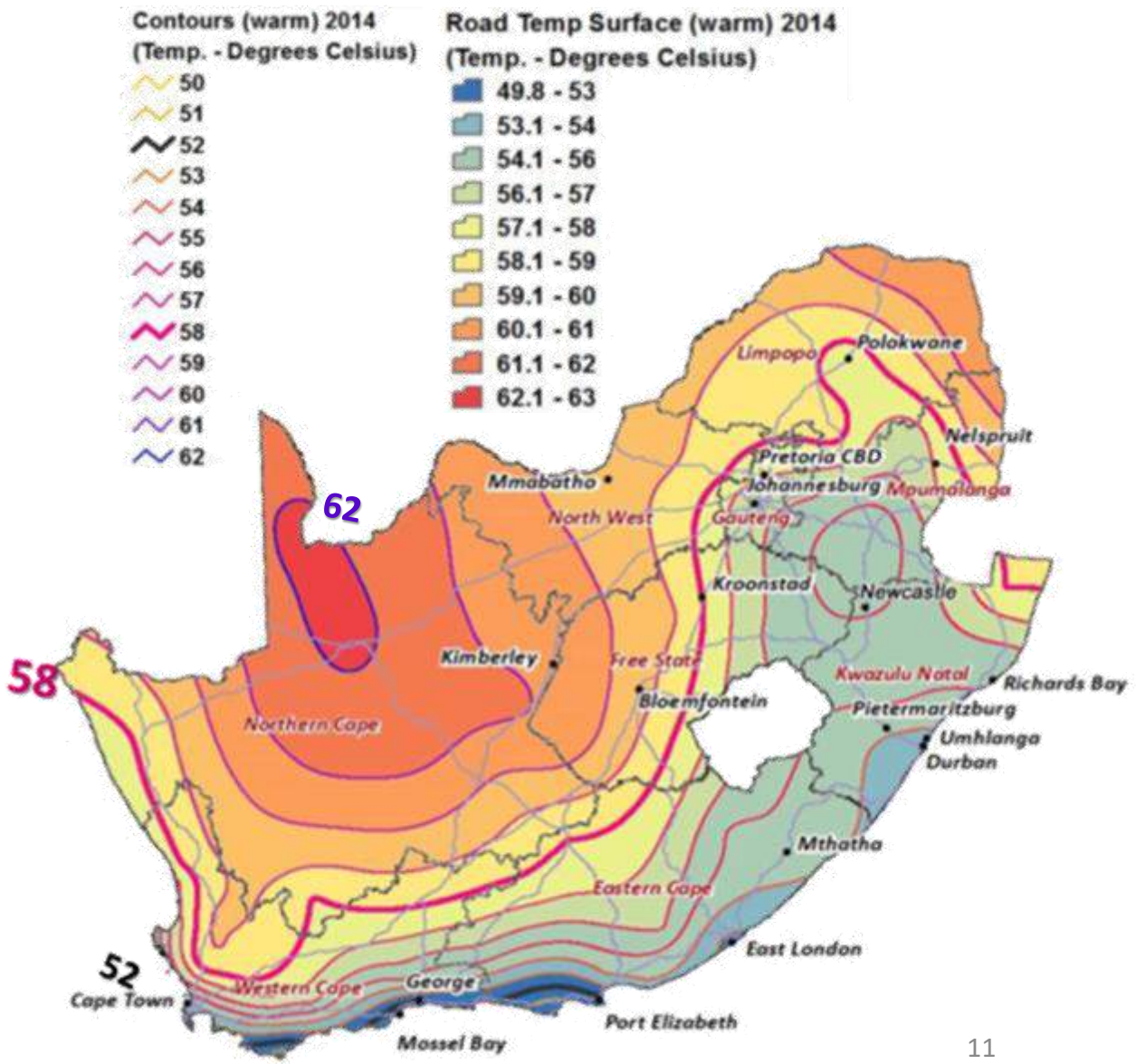
- Following a resolution at the 2015 CAPSA Conference a group of industry, government, university, and other technologists met in Franschhoek, South Africa and drafted a framework over a 2-day period for the implementation of a Superpave binder specification
- The "*Franschhoek Declaration*" became the South African Superpave Specification

Continuing implementation activities

- Performance grading framework and compliance requirements has been largely driven by a body of professional enthusiasts, led by SABITA, in the interests of introducing an element of engineering science into the selection and use of bituminous binders in roads
- Performance Grade Bitumen Implementation Plan
  - Communication plan - stakeholders
  - Workshops and Training Courses
  - Document Update
  - SARDS / SAPEM
  - Promote PG testing
  - Communication Tools
  - Further development of the PG Specification

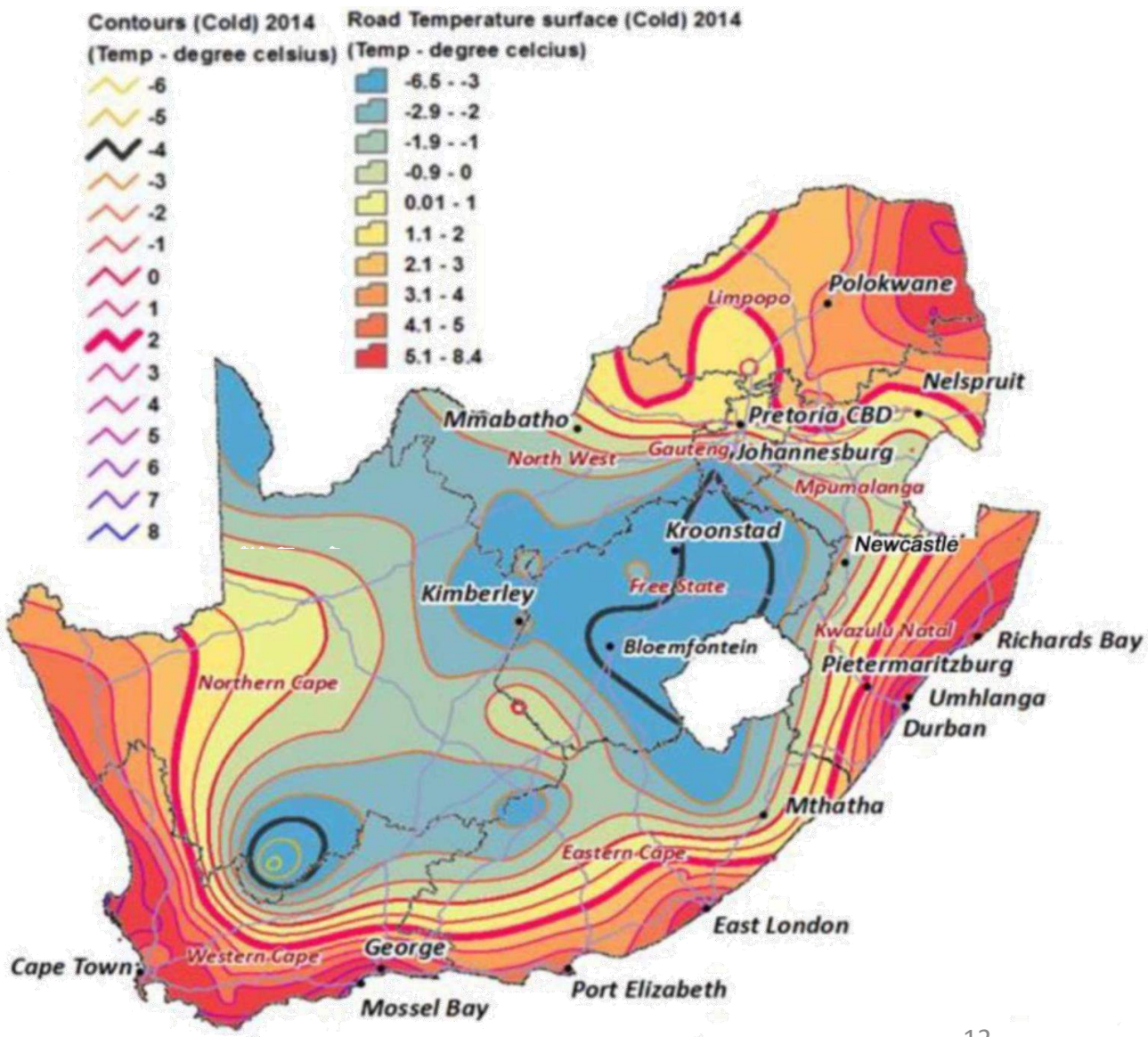
PG High Temperature

- Climate classifies most of South Africa high temperature as a PG64 or PG58
  - PG64 is the northern part of the country
  - Grade bumping considered using MSCR approach
- The maximum road temperature for the operating region for asphalt is to be determined based on the 97.5 % confidence level of recorded temperature measurements taken over seven consecutive days at a depth of 20 mm below the road surface.
  - Does not consider approach associated with “degree day” concept now used in USA
  - Anticipated to change with global warming!



PG Low Temperature

- South Africa's sub-tropical climate does not experience extreme cold temperature events
- The minimum temperature for asphalt is the minimum temperature at 97.5 % confidence level at the road surface
- But, ***UTI = 80 °C*** must be maintained for T_{min}
  - ➢ T_{IT} in low 20's to protect against fatigue



Test Property	Traffic class				Test Method
	S	H	V	E	
Max pavement design temperature (°C)	T_{max}				
Minimum grading temperature (°C)	T_{min}				
Tests on Orginal Binder					
G* and δ at $[(T_{max} + T_{min})/2+4]$°C	Compulsory report only				ASTM D7175
G*/sinδ @10rad/s (kPa) @ $T = T_{max}$ Report G* and δ separately	Compulsory report				ASTM D7175
Viscosity at 165°C (Pa.s) ≥ 30 sec^{-1}	≤ 0.9				ASTM D4402
Storage Stability at 180°C (% diff in G* at T_{max})	≤ 15				ASTM D7175
Flash Point (°C)	≥ 230				ASTM D92b
Tests on Binder After RTFO Ageing (ASTM D2872 / TG1 MB3)					
G* and δ at $[(T_{max} + T_{min})/2+4]$°C,	Compulsory report only				ASTM D7175
Mass Change (% m/m)	≤ 1.0				ASTM D2872 / TG1 MB3
J_{nr} at T_{max} (kPa^{-1})	≤ 4.5	≤ 2.0	≤ 1.0	≤ 0.5	ASTM D7405
Ageing ratio $[G^*_{RTFO} / G^*_{Original}]$	≤ 3.0				ASTM D7175
After RTFO & PAV Ageing (ASTM D6521)					
G* and δ at $[(T_{max} + T_{min})/2+4]$°C,	Compulsory report only				ASTM D7175
Maximum creep stiffness tested at temperature [S (60s) ≤ 300 MPa]	T_{min} + 10°C				ASTM D6648
Minimum m-value tested at temperature [m (60s) ≥ 0.300]	T_{min} + 10°C				
ΔT_c (°C) = $T_{c,S} - T_{c,m}$	≥ -5				ASTM D7643
Ageing ratio $[G^*_{PAV} / G^*_{Original}]$	≤ 6.0				ASTM D7175

PG Specification in a Nutshell

PG Binder-grades

PG58-22, PG64-16, PG70-10

Traffic classes

S = standard

H = High

V = Very high

E = Extreme

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 - 100	E	E	V	III
>100	E	E	E	

Typical bitumen grades

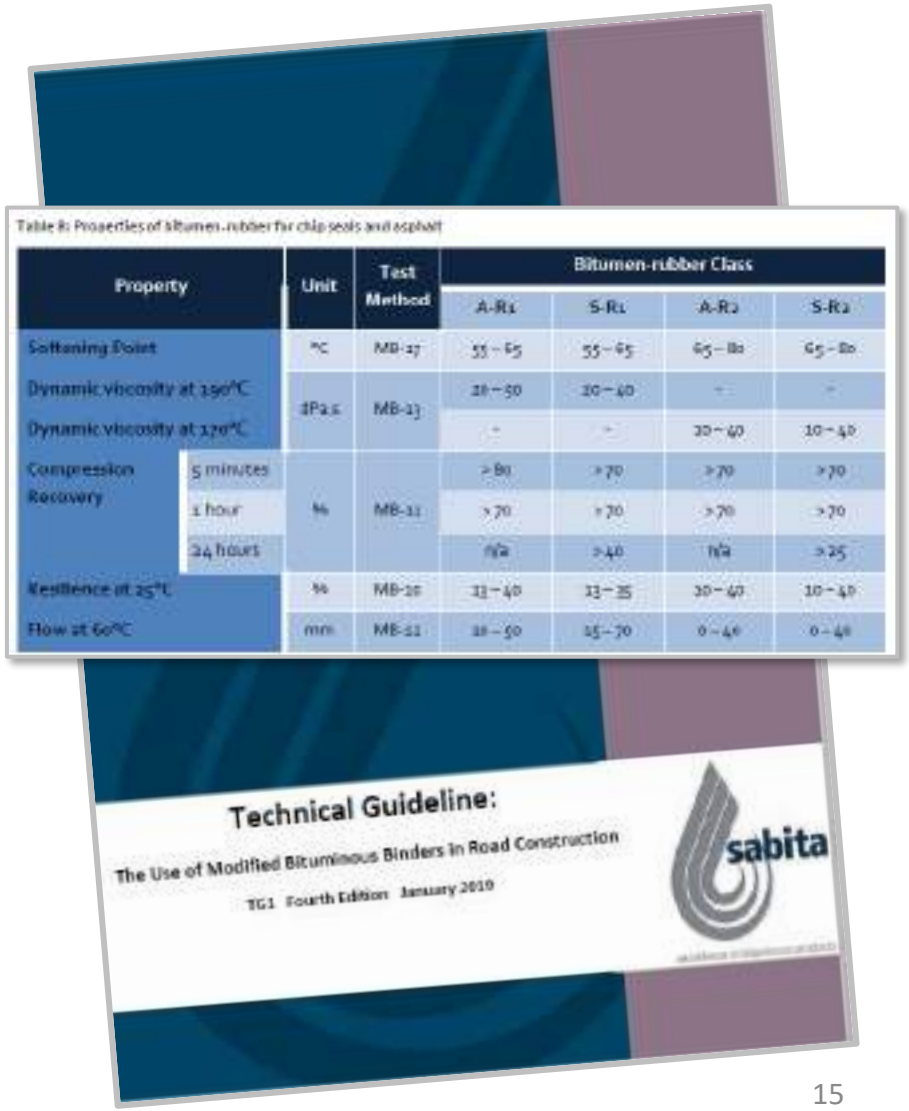
- The Continuous Grading Temperatures and Continuous Grades for PG graded binders reflected in the table shall be determined and reported as per ASTM D7643 and will be determined as follows:
  - T_{max} shall be the temperature where Jnr = the requirement for the S-class traffic, thus Jnr = 4.5;
  - T_{min} shall be maximum temperature determined from testing in the BBR after RTFO and PAV aging, as follows:
    - S(60) = 300 MPa; and
    - m(60) = 0.3.
- A 10/20 penetration grade (PG76-10) shall comply to the following additional requirements:
  - $G^*/\sin\delta \geq 4$
    - ❖ Measured at T_{max} and ω = 10 radians/sec
  - Recovery as determined by the MSCR/Jnr
    - ❖ $\%R \leq 10\%$
  - Use for EME as a hard binder (no modifier)
- Test protocol described in **SABITA Manual 39**

SANS 4001-BT1	SATS 3208 Continuous Grades
10/20	PG76-10
35/50	PG64-16
50/70	PG64-16
70/100	PG58-22

http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1021-20192019000300003&lng=en&nrm=iso&tlng=en

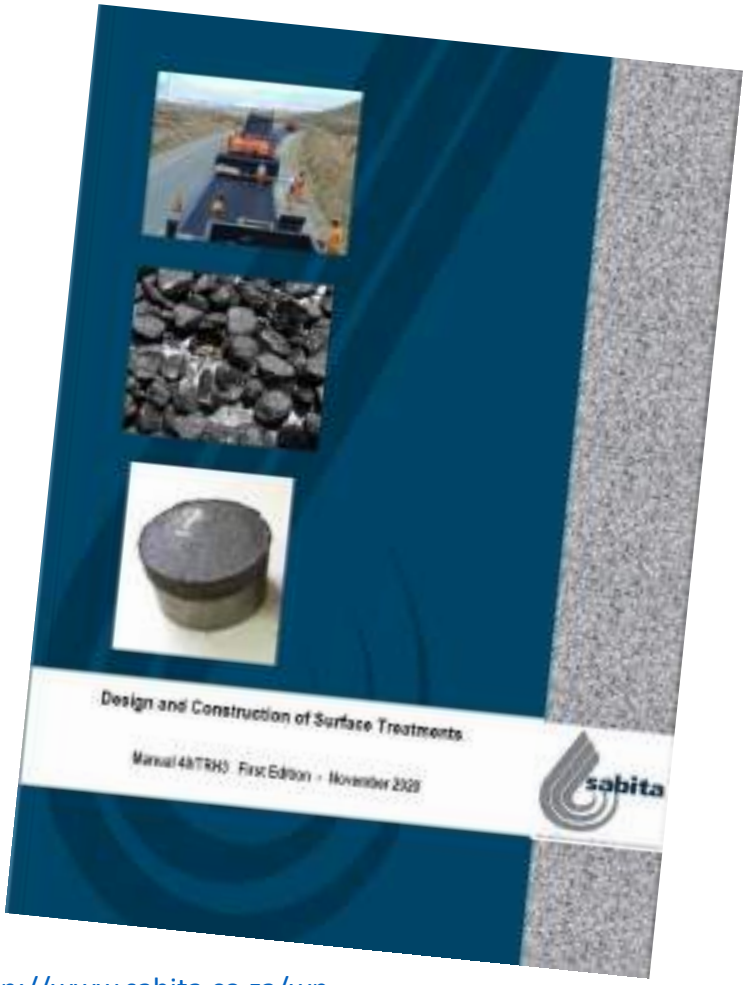
Non-homogeneous binder (Bitumen Rubber)

- Heterogeneous binders in SA known as A-R1 and A-R2, the latter contains FT-waxes, manufactured to TG1
  - A-R1 short shelf life, thus manufactured on site
  - A-R2 shelf life > 7days, thus manufactured in plant
- Max crumb size is 1 mm with ca. 70% passing 0.6mm sieve, 20% rubber crumbs in the binder
- PG specification is binder blind, therefore equivalent PG grade is PG76-22(CRM), the CRM denote crumb rubber modification
  - Should ΔTc ≥ -5°C not be met, then
    - ΔTc ≥ -7°C plus Glover-Rowe ≤ 180 kPa
  - $\%R_{Jnr} \geq 45\%$



Surfacing Seals - SABITA Manual 40 (TRH3)

- PG Specification not officially implemented for surfacing seals
  - However, implementation per project is allowed
- Keep it simple, use SATS 3208 for spray-grade binders, except:
  1. Adjust definition of T_{max} for surfacing seals, $T_{max, seal} = T_{max} + 3$ °C
  2. Research by Engelbrecht (2018) showed that all spray-grade binders comply with SATS 3208 PG Specification
- For emulsions the PG specification will be applied on RTFOT residue

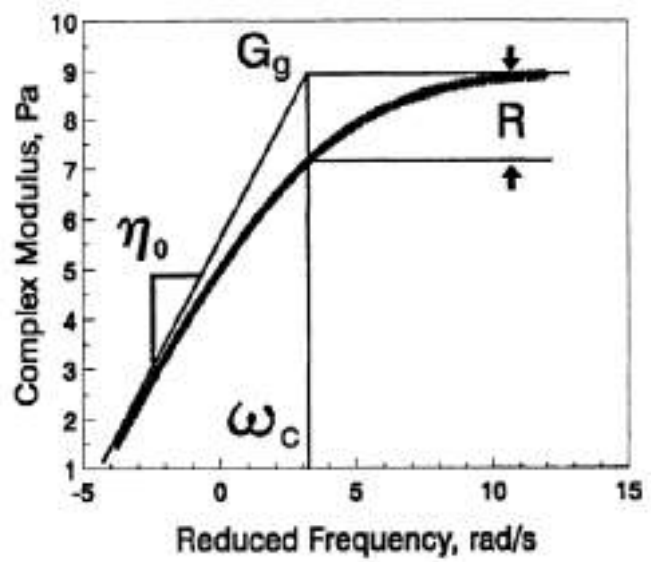


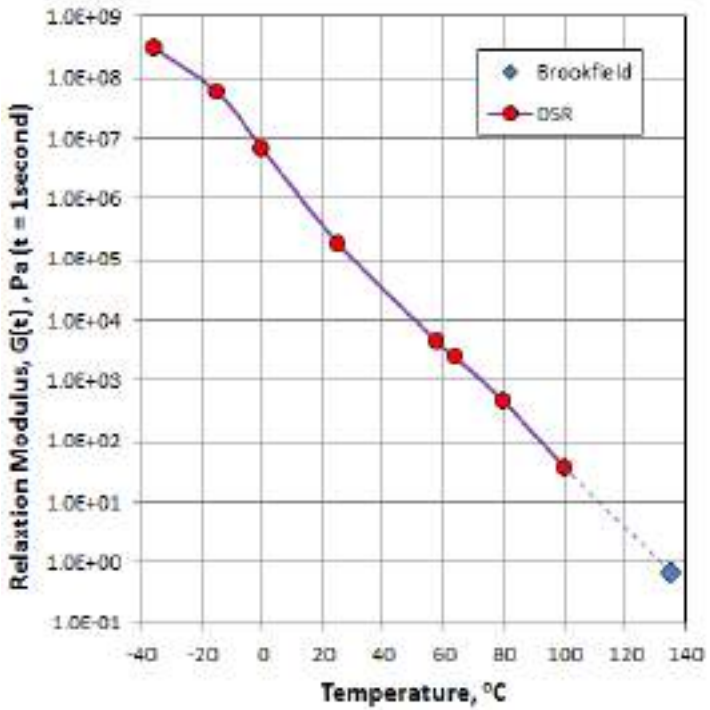
http://www.sabita.co.za/wp-content/uploads/2020/11/manual-40-trh-3-nov-2020.pdf

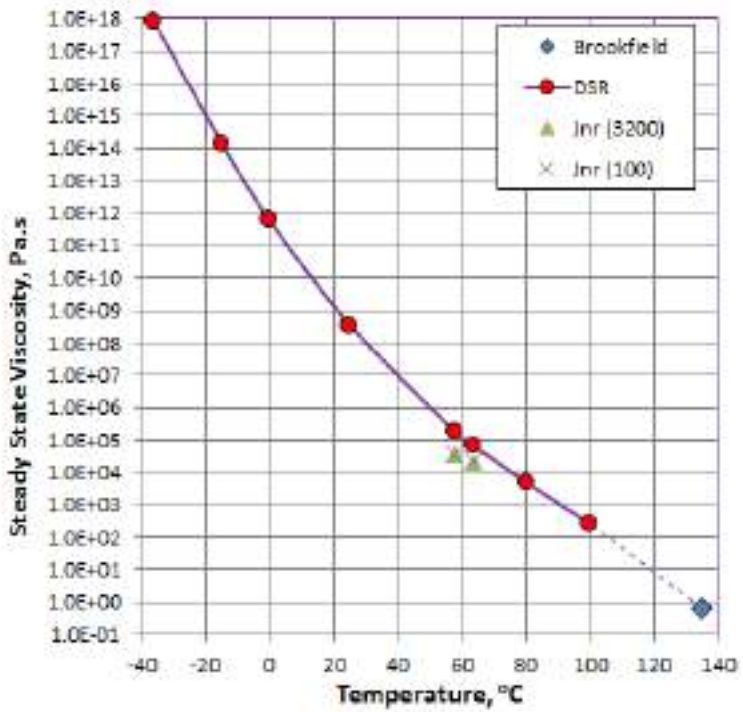
Site Quality Control

- 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

Horses for courses – large contracts can afford larger and more sophisticated site laboratories

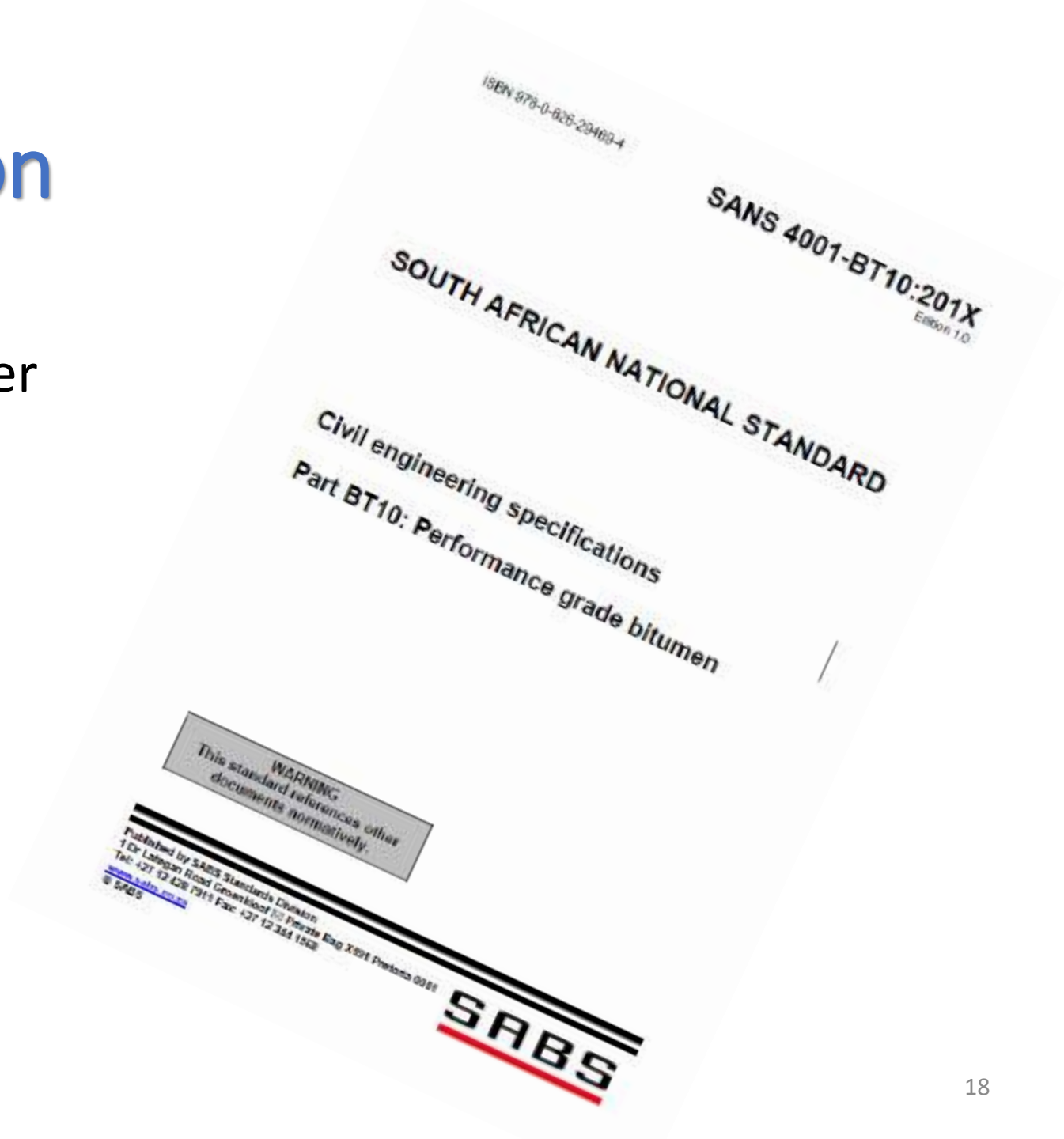






Final Implementation

- Implementing the PG Specification to achieve better asphalt pavement lifetime



Resolution: That the RPF support the implementation of the PG Specification

Questions?
Comments!