sabita

excellence in bituminous products

# Development and Implementation of a Performance Grading System for South African Binders

## Update from RPF PG Binder Working Group

Pretoria, South Africa

11th November 2015

tellenbosch

THE SOUTH AFRICAN NATIONAL ROADS AGENCY SOC LTD

Reg. No.1998/009584/06

# Salvador Dali

# Resolution 1

***The conference charges Sabita to convene an international binder expert group meeting in 2015, to process the PG concepts developed at CAPSA 15, for the purpose of formulating a PG specification for trial implementation by SANRAL***

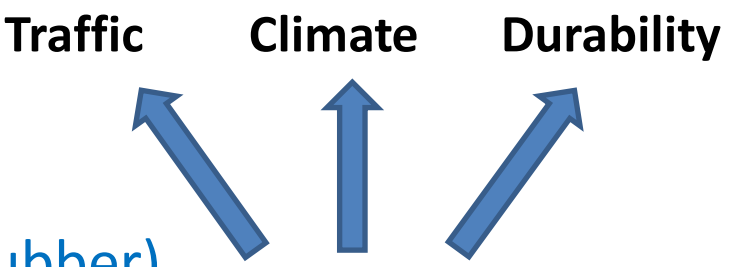
**(August 2015)**

# Key questions

- What are we aiming to achieve with PG specs?
- What is the benefit to industry?
- An entirely fundamental, theoretical specification is unlikely... Healthy dose of empiricism?
- Implementable protocols for Specs?
  - Product “fitness for purpose”
  - Site QC

# Primary Objectives

- **Binder blind**
  - unmodified
  - PMBs
  - non-homogenous (bitumen rubber)




- **Binder "fitness for purpose" in asphalt and seals**
- **Use DSR as extensively as possible**
- **Address all stages & conditions of usage:**
  - Spraying, mixing and compaction
  - High temperature (permanent deformation)
  - Intermediate temperature (fatigue)
  - Low temperature (cracking)…if necessary

# The Franschoek Declaration *16 Oct '15*

# Clear Message

Get those thinking caps on!


**SPEC IN THE KEP**

# Imperatives of PG Spec

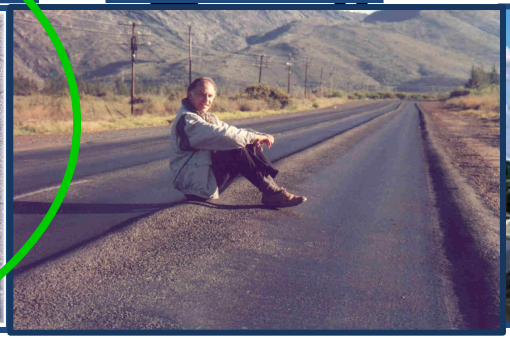
- Simplicity (protocols, operator training, time)
- Reliability (repeatability, reproducibility)
- Applicability (mirror reality, central and site lab?)
- $\text{Versatility}_1$ (binders: straight, mod, non-hom)
- $\text{Versatility}_2$ (range of temperatures, frequencies)
- Durability (ageing)
- Resource Economy (DSR + RV? + ?)
- Limits (ranking intervals vs $\text{limits}_{\text{upper/lower}}$)

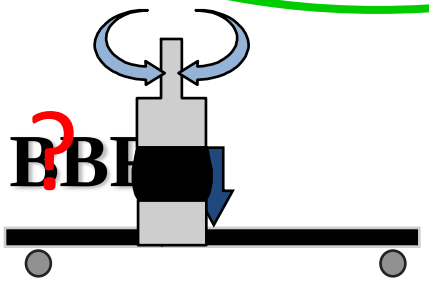
# PG System

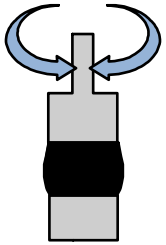
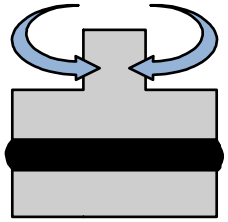
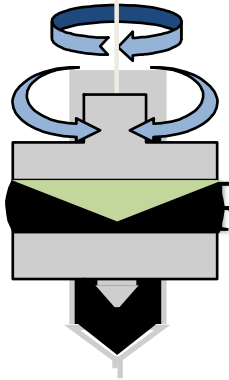
combine?

*Thermal Cracking* | *Fatigue Cracking* | *Rutting* | *Production*





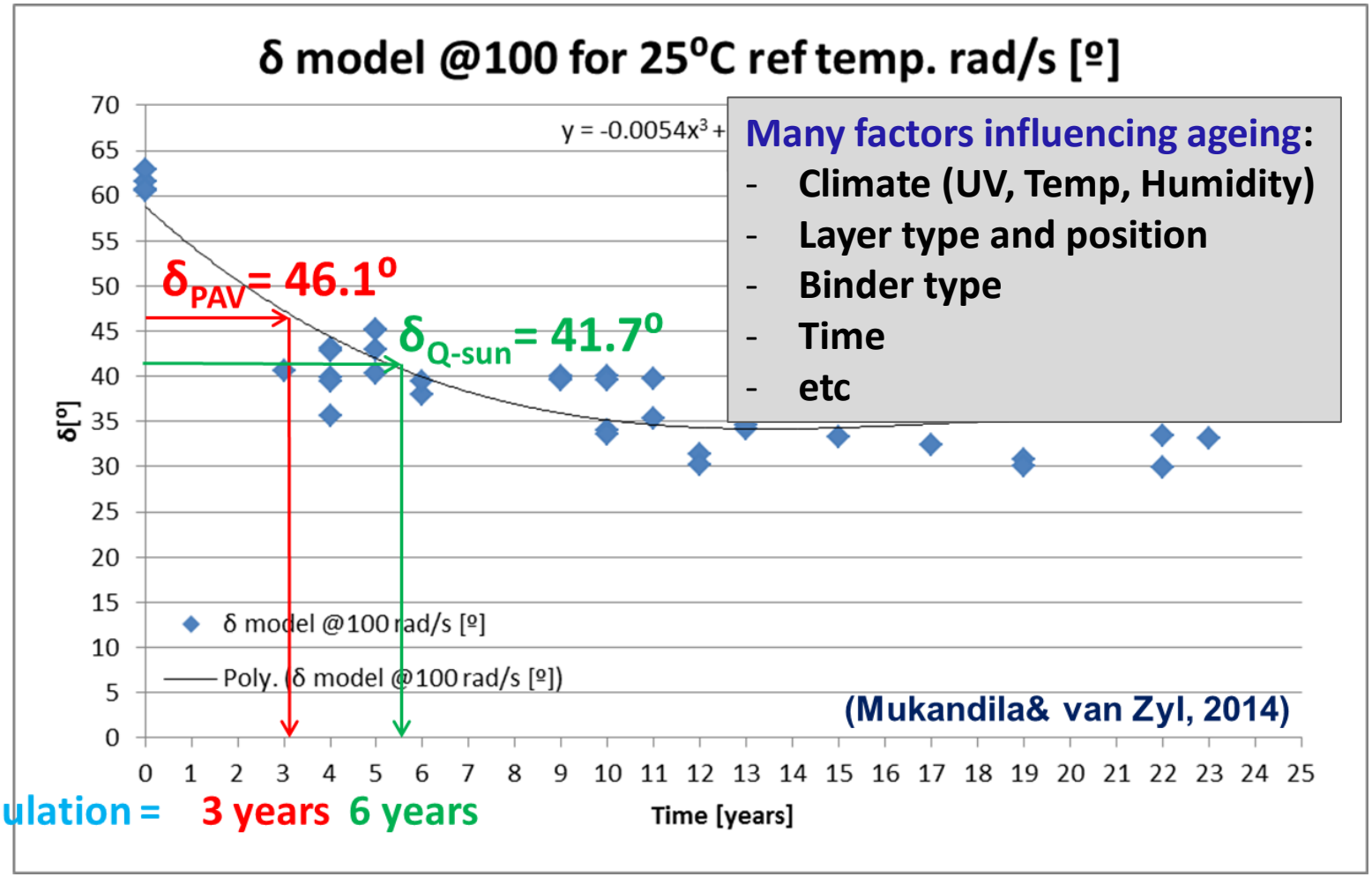

DSR




- 20 $^0$C | 20 $^0$C | 60 $^0$C | 135 $^0$C

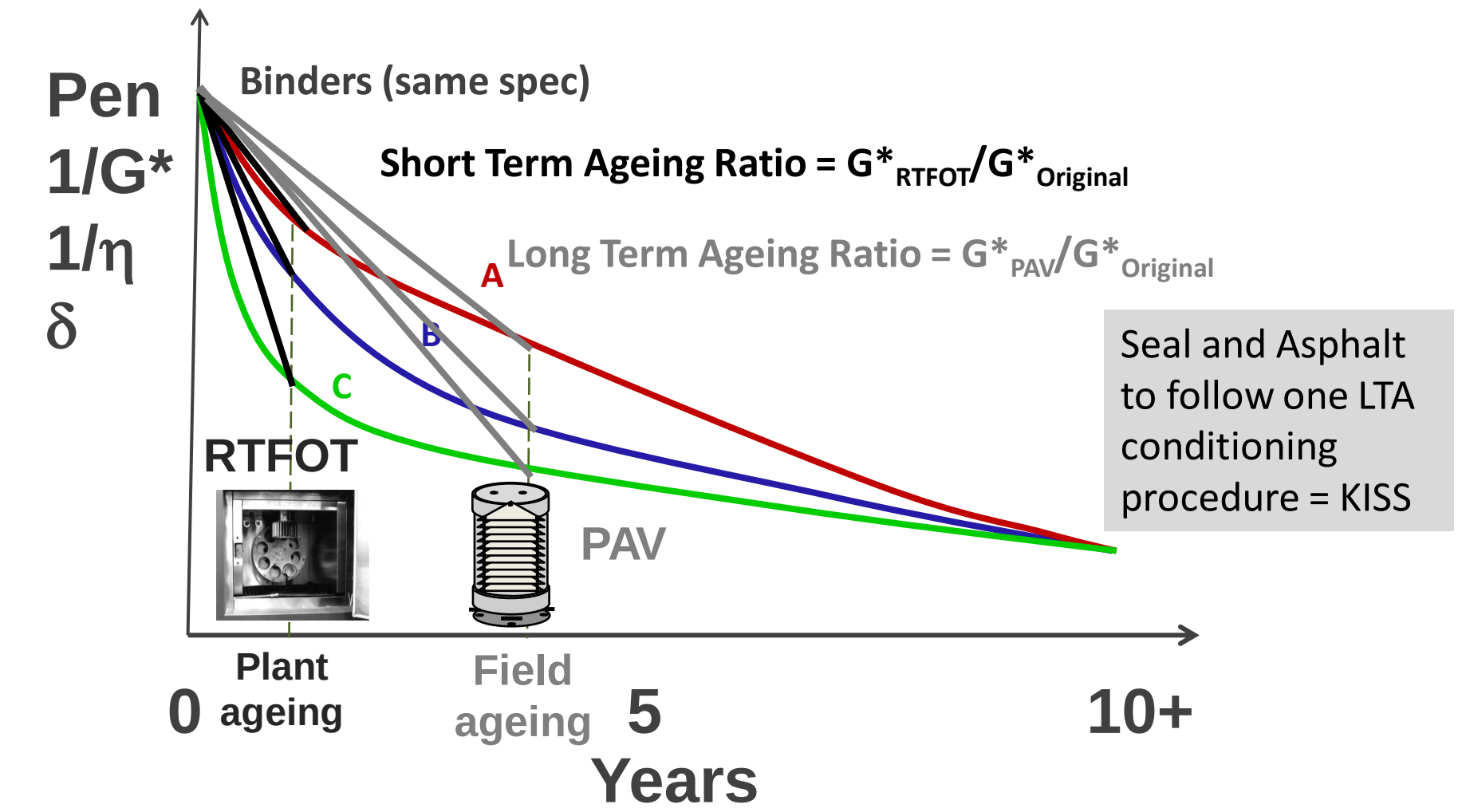
**Pavement Temperature**

# Ageing Simulation (STA & LTA)

– Standard PAV hopelessly underestimates field ageing e.g. 3 years equivalent not 10 yrs

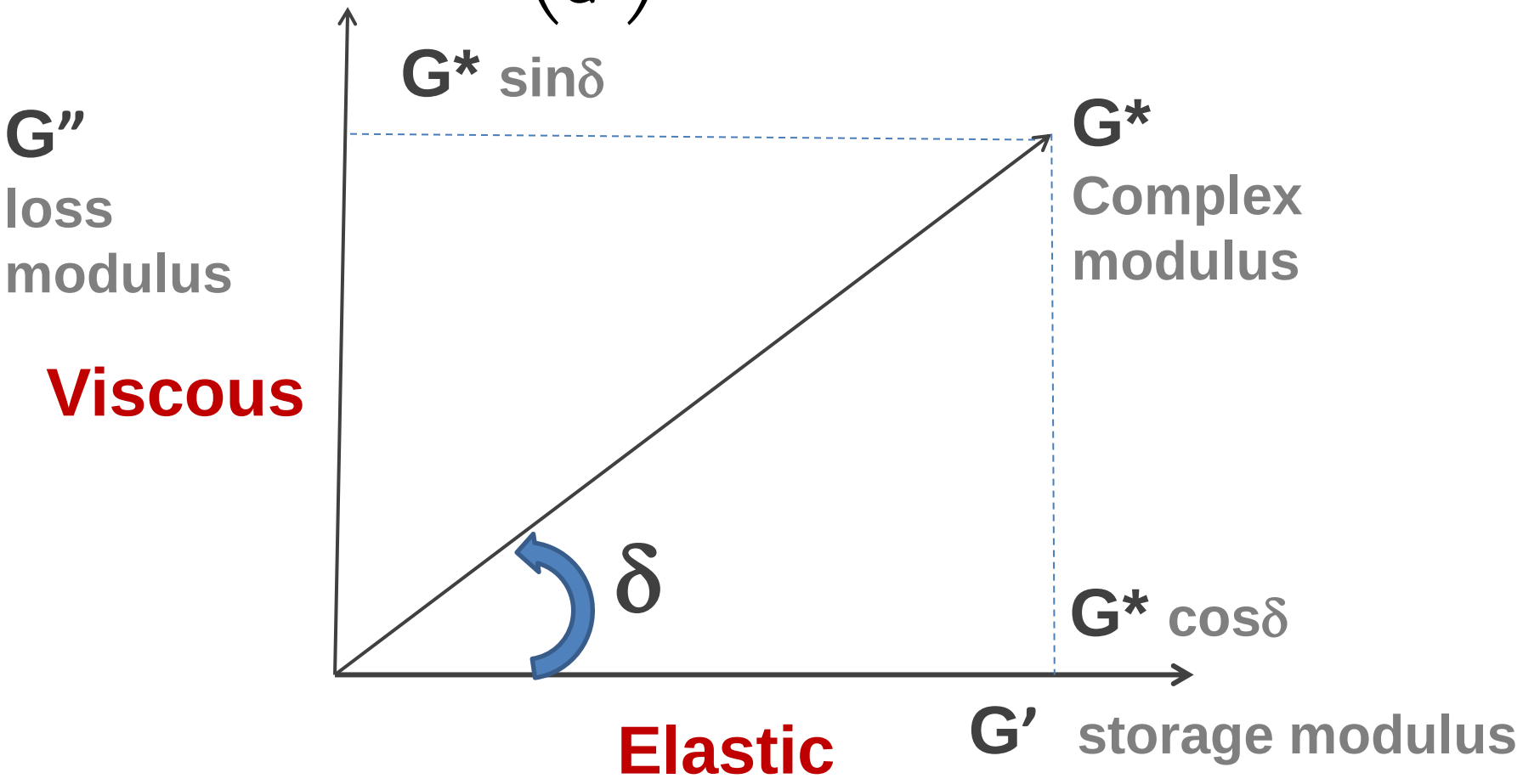


# Ageing Simulation



# Select Performance Parameter for Ageing (Glover – Rowe GR)

$$GR = G'/\left(\frac{\eta'}{G'}\right) = G^{*} \times ((cos\delta)^2/sin\delta)$$

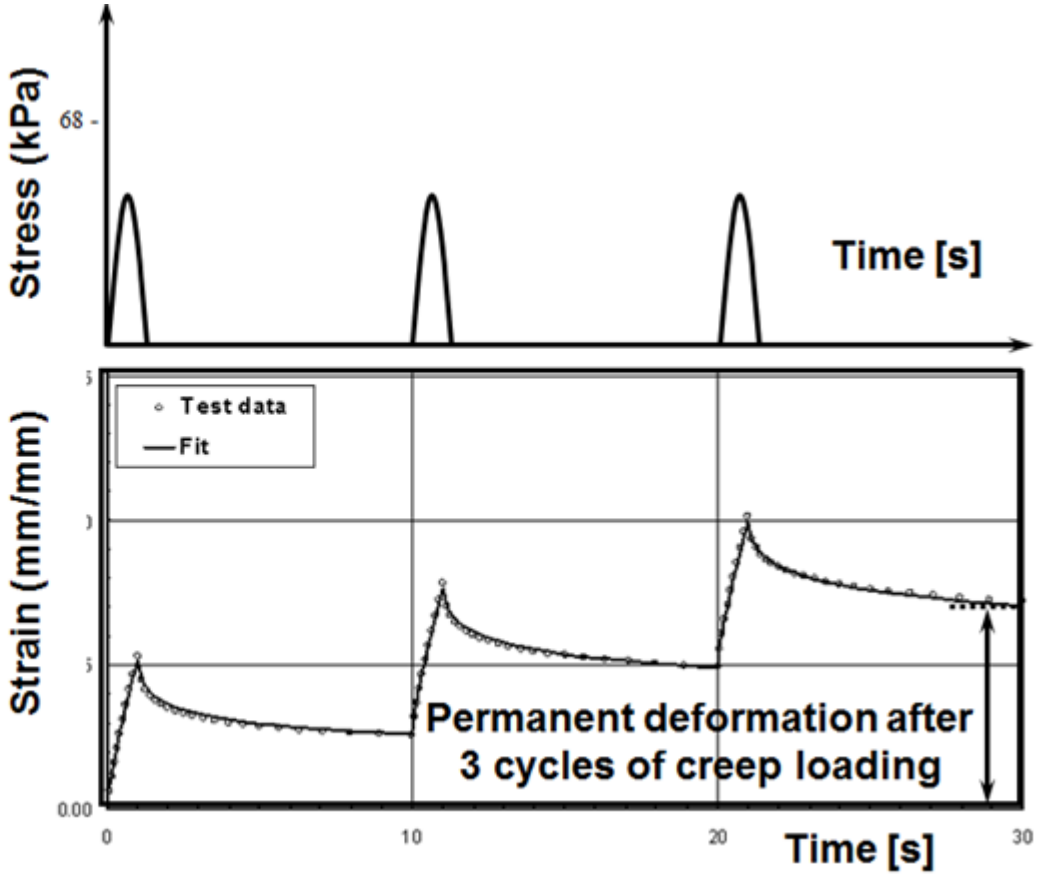


# PG Specification Framework

| Property | Proposed Classification | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 58S | 64S | 58H | 64H | 58V | 64V | 58E | 64E |
| | -22 | -16 | -22 | -16 | -22 | -16 | -22 | -16 |
| Maximum pavement design temperature, $T_{max}$ (˚C) | 58 | 64 | 58 | 64 | 58 | 64 | 58 | 64 |
| Minimum grading temperature, $T_{min}$ (˚C) | -22 | -16 | -22 | -16 | -22 | -16 | -22 | -16 |
| **Original binder** | | | | | | | | |
| G*/sinδ, 10rads/sec at $T_{max}$, minimum | 1.0 | 1.0 | N/A | | | | | |
| G*, δ, @ 0.05 to 20 rads/sec, at ([($T_{max}$-$T_{min}$)/2]+4) ˚C | Report | | | | | | | |
| Viscosity (Pa.s), 135˚C, maximum | 3.0 | | | | | | | |
| Flash Point (˚C), minimum | 230 | | | | | | | |
| Storage stability, Max % diff, $G^*_T$ and $G^*_B$ @$T_{high}$ | 10 | | | | | | | |
| **RTFO binder** | | | | | | | | |
| Maximum Mass Change (m/m %) | 1.0 | | | | | | | |
| $J_{nr}$ (ASTM D7405) @ $T_{high}$, maximum | 4.5 | 4.5 | 2.0 | 2.0 | 1.0 | 1.0 | 0.5 | 0.5 |
| G*, δ, @ 0.05 to 20 rads/sec, at ([($T_{max}$-$T_{min}$)/2]+4)°C | Report | | | | | | | |
| Ageing Ratio, $G^*_{RTFOT}/G^*_{Original}$, maximum (10rads/sec) | 3.0 | | | | | | | |
| **PAV binder** | | | | | | | | |
| S(60s) at $T_{min}$ + 10°C , MPa, maximum | 300 | | | | | | | |
| m(60s) at $T_{min}$ + 10°C, minimum | 0.300 | | | | | | | |
| $\Delta T_c$(°C), minimum | -5 | | | | | | | |
| G*, δ, @ 0.05 to 20 rads/sec, at ([($T_{max}$-$T_{min}$)/2]+4)°C | Report | | | | | | | |
| Ageing Ratio, $G^*_{PAV}/G^*_{Original}$, maximum (10rads/sec) | 6.0 | | | | | | | |

# Permanent Deformation: Creep and Recovery (MSCR)

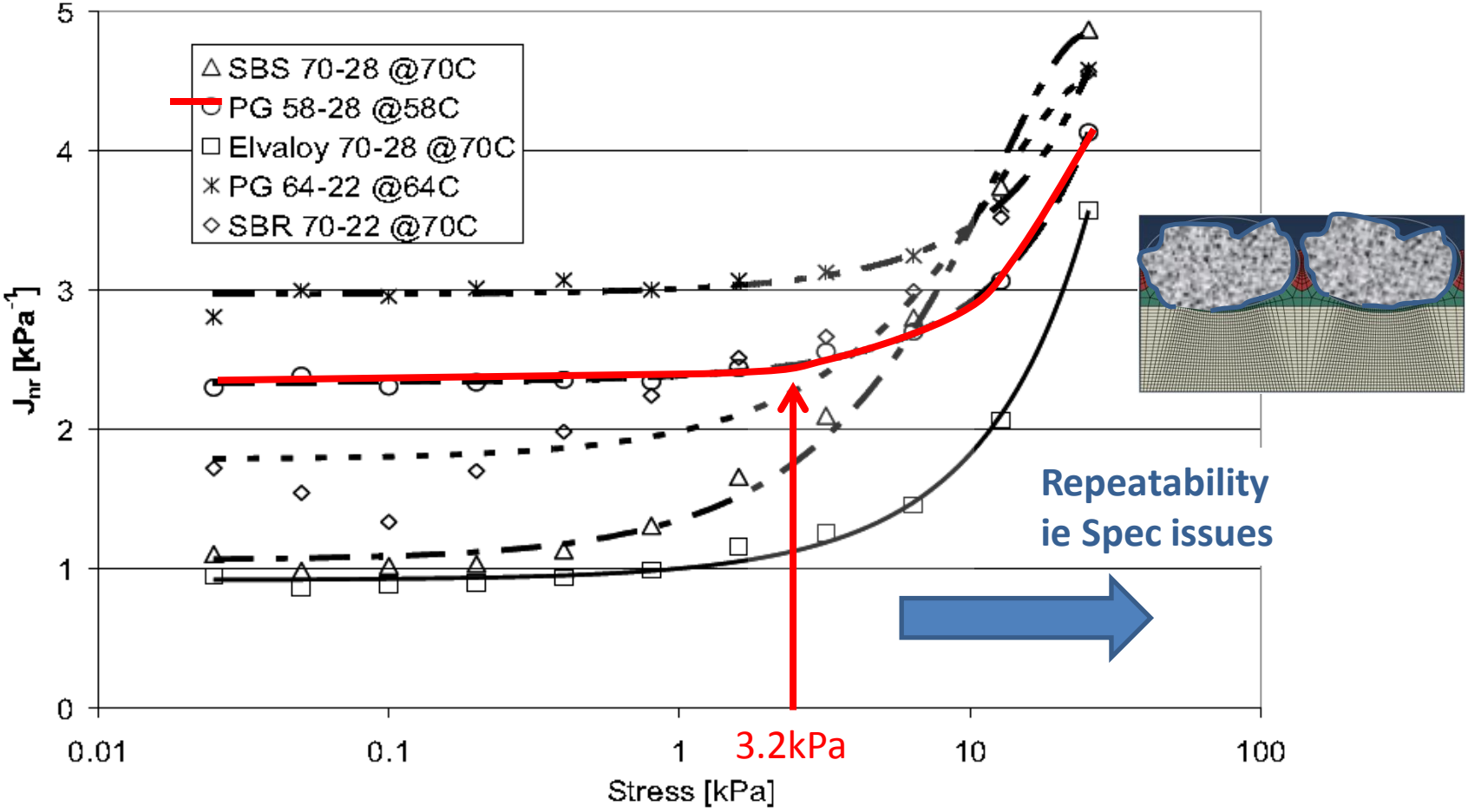
Repeated Creep Loading




$$J_{nr} = \frac{\text{Ave permanent shear strain (non-recov) per cycle}}{\text{Applied shear stress}}$$

AASHTO TP70

# Findings of PG Spec Research

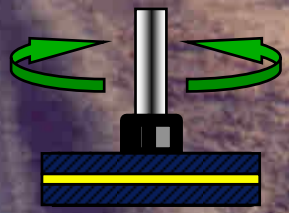



D'Angelo *et al*

# Outcomes of Franschoek Meeting$_2$

## Permanent Deformation DCR

### Dynamic Creep Recovery



| | |
|---|---|
| **Industry Protocol** | **// Plate @ $\tau$ = 0.1 & 3.2 kPa for 10 cycles each (measure last 5) CSIR and AASHTO T350 methods** |
| Trial Implementation | // Plate @ $\tau$ = 0.1 & 3.2 kPa measure 10 and 20 cycles |
| Comments | For standard traffic levels, G*/sin$\delta$ should suffice, for unmodified binders |

Photo: G v Zyl

# Durability Cracking


- Testing at IT and LT
- Parameters Consider R, $\Delta T_c$ , G-R parameter, etc

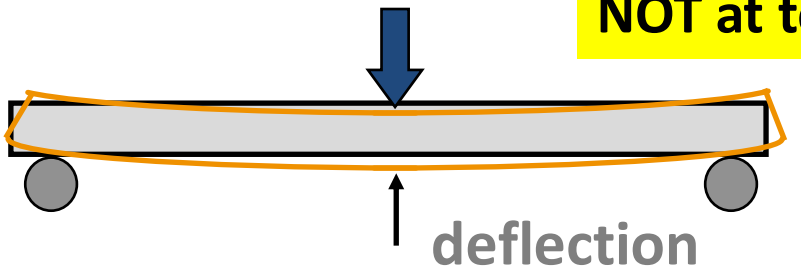
**Notes for Durability Tests**

**DSR for s,m: COV=40%, more expensive, less bit, BR?**

**BBR for s,m: COV=4%, cheaper, more binder, non-homog**

**DSR (4mm)**

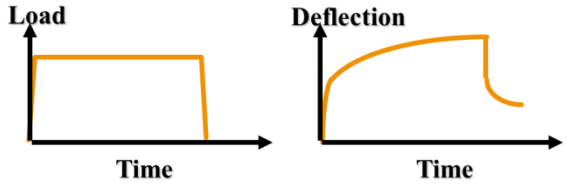
**BBR**



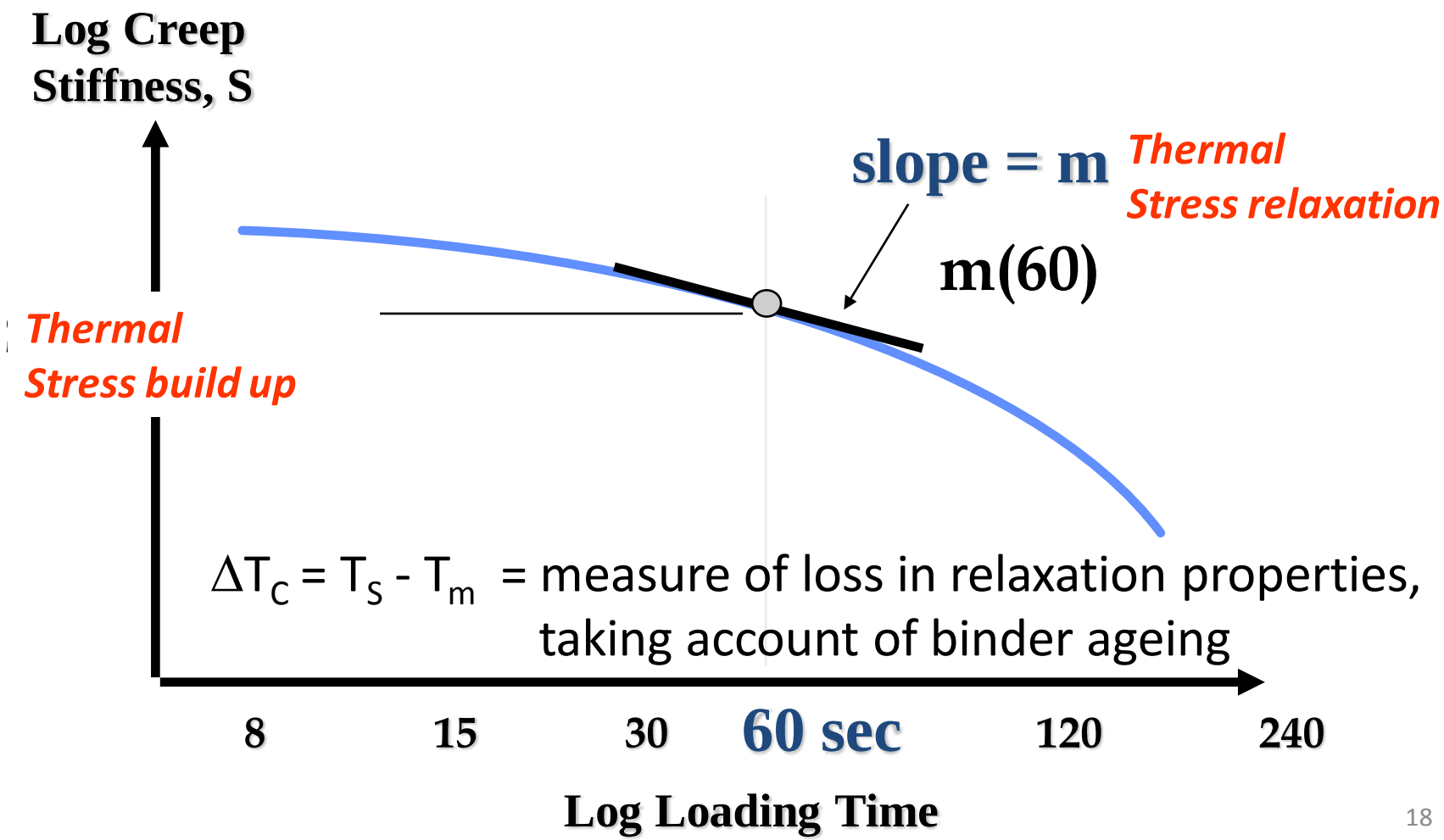

**Note**

**$T_{min}$ = -16$^0$C is a durability check**

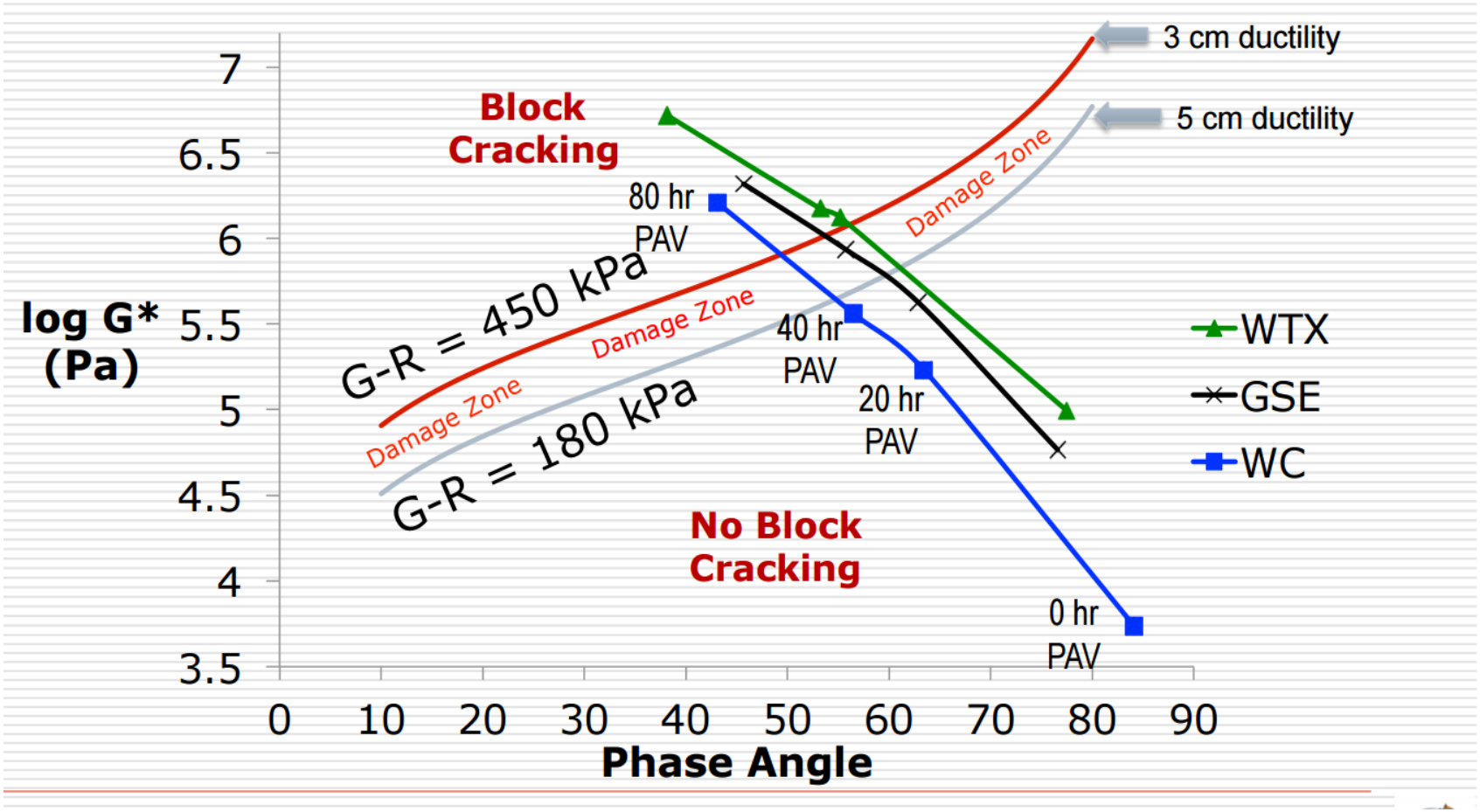
**NOT at test at -16$^0$C !!**



# Results of Bending Beam Rheometer

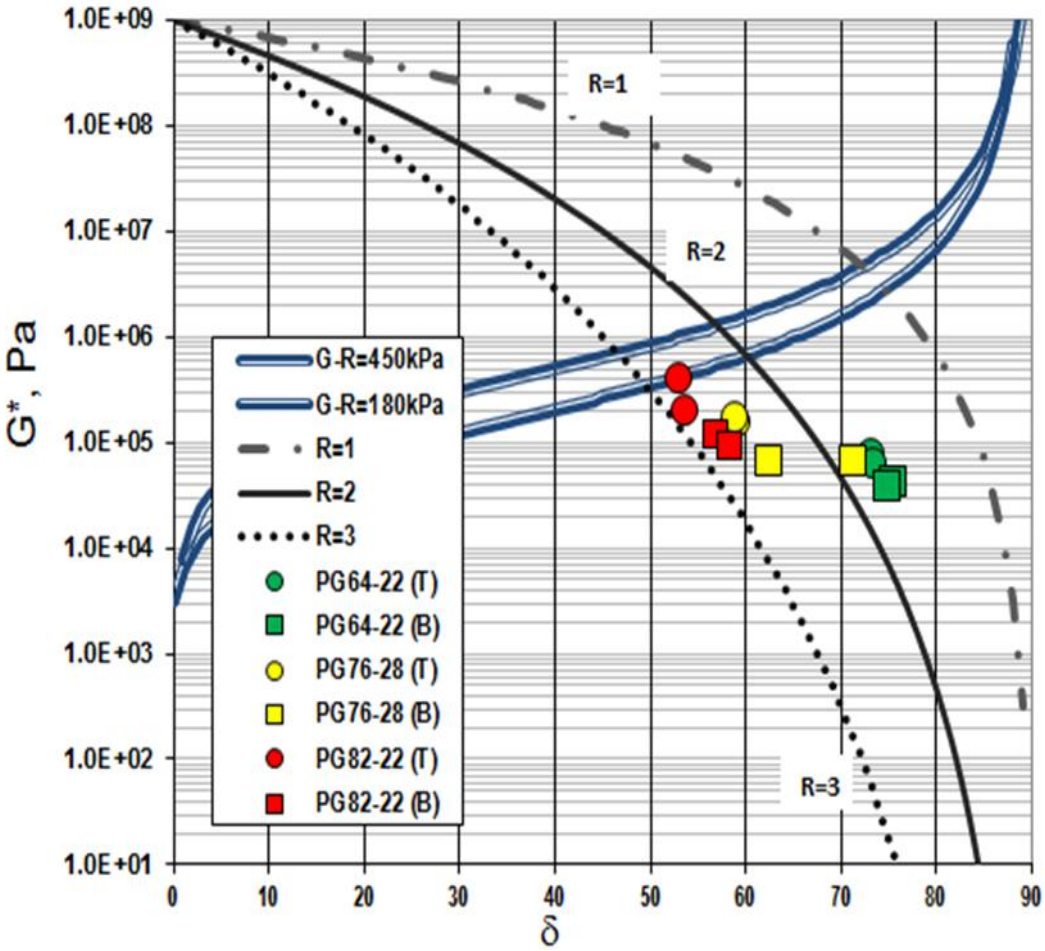


# Cracking: Glover-Rowe Parameter




**G* Test Parameters @ T=15$^0$C and Fr = 0.005 rad/sec**

# Parameters for IT and LT damage



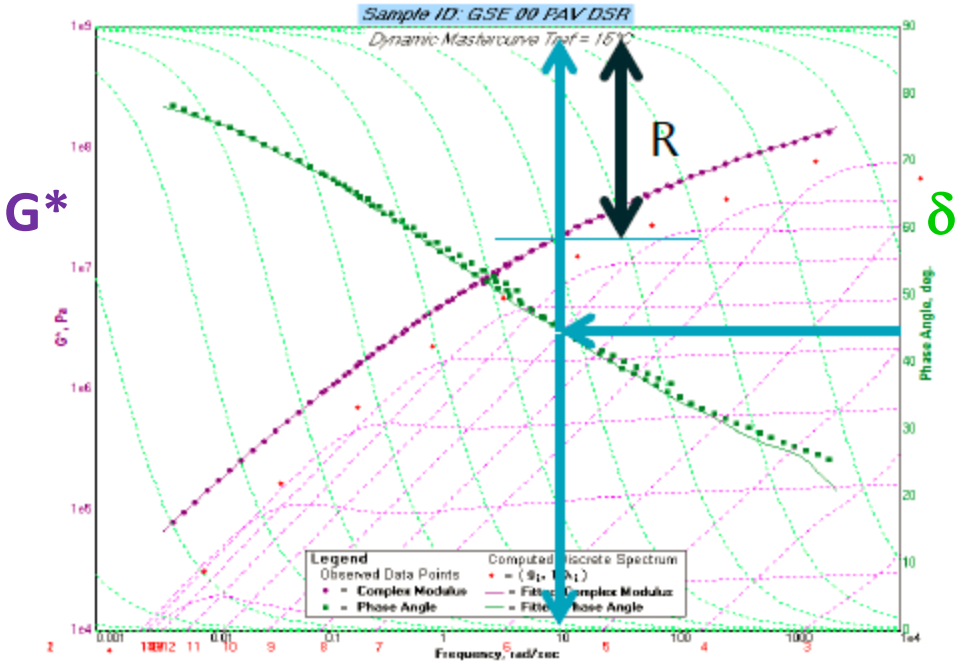

(Rowe, 2015)

**DSR Parameters:** R (Master Curve), G-R parameter (Black Diagram)

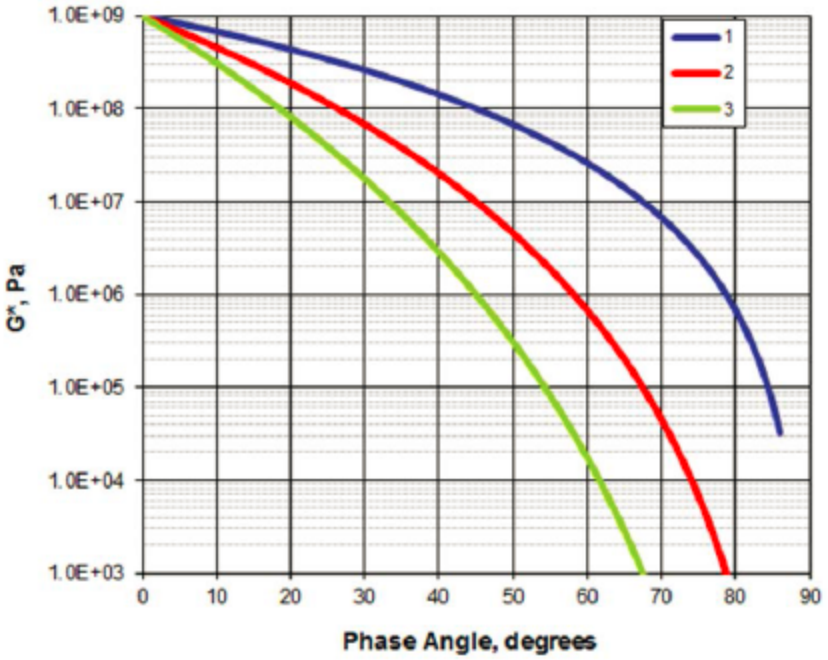
# R-value

- Easy to compute from single data points
- Place in Black space linked to R
- Cross-over frequency, VET, G-R or other parameters such as NCSU $\delta$ =45 all related to R-value
- Field performance shows cracking is related to R
- All interrelated via VE-time temperature functions

(Rowe)

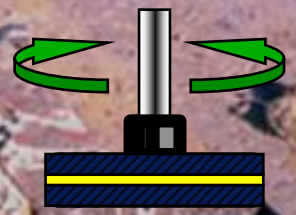



$\omega_o$



# Durability Cracking

## Stress relaxation properties for IT and LT damage



| Industry | BBR test for S (60) and m (60)<br>$\Delta T_c$ min = -5$^0$C |
|---|---|
| Industry report | DSR //P @ Strain sweep G*, $\delta$, @ 0.05 to 20 rads/sec, at ([($T_{max}$-$T_{min}$)/2]+4)$^o$C |
| | Evaluate R, G-R parameter from DSR data |

Photo: CSIR

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| **Original binder** | | | | | | | | |
| G*/sinδ, 10rads/sec at $T_{max}$, minimum | 1.0 | 1.0 | N/A | | | | | |
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| Viscosity Pa.s, 135˚C, Pa.s, maximum | 3.0 | | | | | | | |
| Flash Point (˚C), minimum | 230 | | | | | | | |
| Storage stability, Max % diff, $G^*_T$ and $G^*_B$ @$T_{high}$ | 10 | | | | | | | |
| **RTFO binder** | | | | | | | | |
| Maximum Mass Change (m/m %) | 1.0 | | | | | | | |
| $J_{nr}$ (ASTM D7405) @ $T_{high}$, maximum | 4.5 | 4.5 | 2.0 | 2.0 | 1.0 | 1.0 | 0.5 | 0.5 |
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| Ageing Ratio, $G^*_{PAV}/G^*_{Original}$, maximum (10rads/sec) | 6.0 | | | | | | | |

DSR BBR

# Outcomes of Franschoek Meeting 1

## Production & Construction

### Spray, Pump, Mix, Pave

| | |
|---|---|
| **Industry** | **C&B or RV @ 135°C**<br>**Spec $\eta_{max}$ = 3Pa.s**<br>**EN13702 and Anton Paar Method** |
| Research – Currently underway | Calibration RV vs C&B (JvH) |

Photo: K Louw

# Binder Recovery

| Industry | Rotary Evaporator (agreed in Franschoek) |
|---|---|
| Activity - Priority | Research complete at CSIR. GM has drawn up protocol for Rotor-Vapour based on research. |
| | Bit Mat Committee- distributed draft protocol for comment. Solvent type is important |

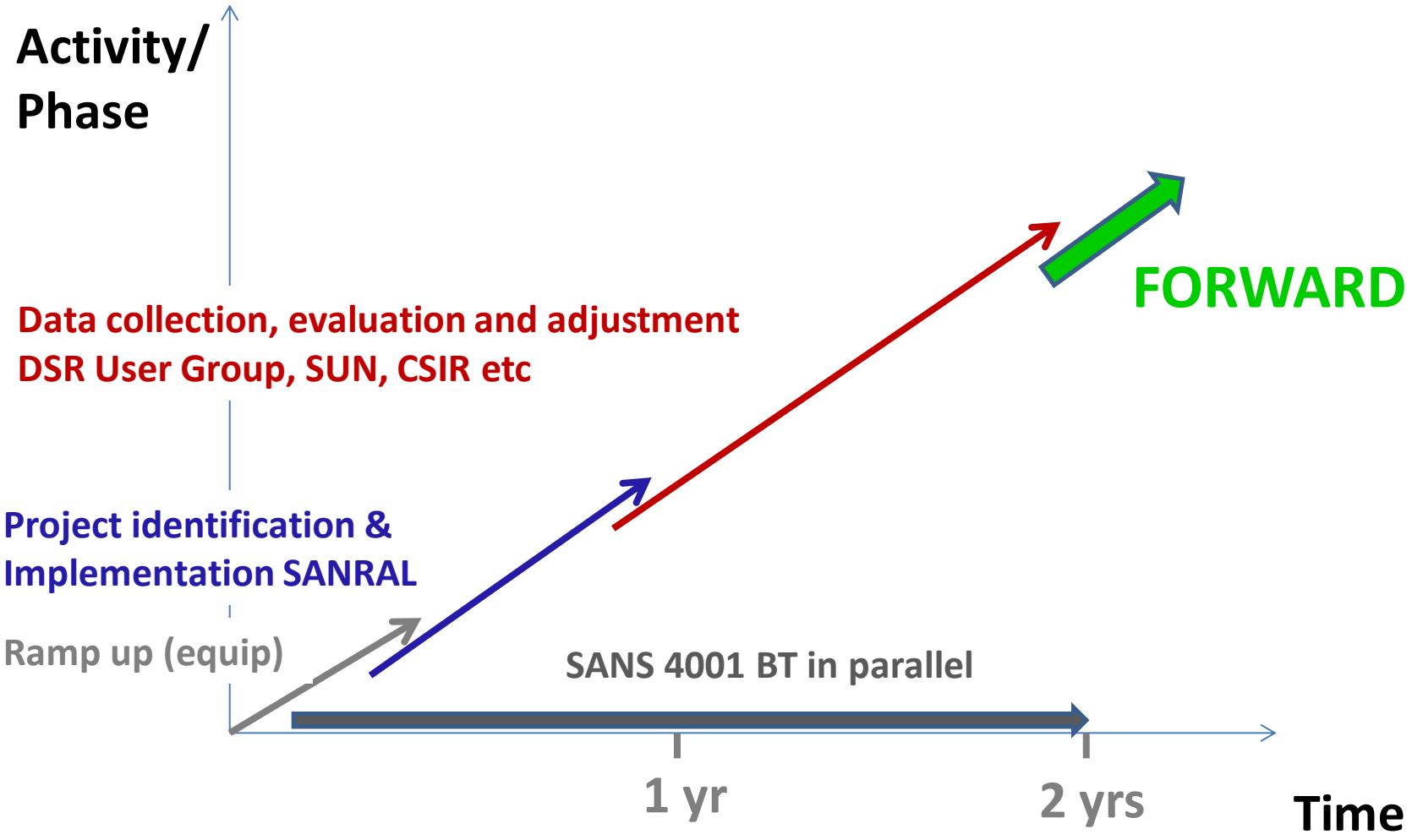
# Benefits of PG Spec for SA?

- Binder selection based on traffic, climate
- Product innovation reliably assessed
- Permanent deformation reliably evaluated
- Long Term Ageing finally assessed, for thin layers in SA context!!
- Durability – stress relaxation holistically assessed (not fatigue versus LT fracture)
- Resource economy in test apparatus & methods (but bitumen sample size IT and LT!)
- No binder grade proliferation

# Implementation Plan

- SANRAL to implement PG specs for roads projects in parallel to existing spec for 2 years
- Data from DSR to be processed for G-R, R etc by CSIR and SUN. Can feed into SARDS d-base
- SANRAL to support high impact rheological research to fill gaps
- Launch to be coordinated by SANRAL/Sabita
- PG binder lab certification course to be organised

# Implementation Plan



# Joining the curve at an elevated level!

Thank you!

# PG BINDER SPECIFICATIONS RESEARCH

**Steph Bredenhann**

30th Road Pavements Forum

11 November 2015

THE SOUTH AFRICAN NATIONAL ROADS AGENCY SOC LTD
Reg. No.1998/009584/06

# Proposed specification

| Property | Proposed Classification | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 58S −22 | 64S −16 | 58H −22 | 64H −16 | 58V −22 | 64V −16 | 58E −22 | 64E −16 |
| Maximum pavement design temperature (˚C) | 58 | 64 | 58 | 64 | 58 | 64 | 58 | 64 |
| **Original binder** | | | | | | | | |
| G*/sinδ, 10rads/sec at $T_{high}$, minimum | 1.0 | 1.0 | N/A | | | | | |
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| Viscosity Pa.s, 135ºC, Pa.s, maximum | | | | | | | | |
| Flash Point (˚C), minimum | | | | | | | | |
| Storage stability, Max % difference, $G^*_T$ and $G^*_B$ | | | | | | | | |
| **RTFO binder** | | | | | | | | |
| Maximum Mass Change (m/m%) | 1.0 | | | | | | | |
| $J_{nr}$ (ASTM D7405) @ $T_{high}$, maximum | .5 | 4 | 2.0 | 2.0 | 1.0 | 1.0 | 0.5 | 0.5 |
| G*, δ,0.05 to 20 rads/sec, at ([($T_{max}$−$T_{min}$)/2]+4)ºC | Report | | | | | | | |
| Ageing Ratio, $G^*_{RTFOT}/G^*_{Original}$, maximum (10rads/sec) | 3.0 | | | | | | | |
| **PAV binder** | | | | | | | | |
| S(60s) at $T_{min}$ + 10ºC , MPa, maximum | 300 | | | | | | | |
| m(60s) at $T_{min}$ + 10ºC, minimum | 0.300 | | | | | | | |
| ·T(c), ASTM D????, minimum | −5 | | | | | | | |
| G*, δ,0.05 to 20 rads/sec, at ([($T_{max}$−$T_{min}$)/2]+4)ºC | Report | | | | | | | |
| Ageing Ratio, $G^*_{PAV}/G^*_{Original}$, maximum (10rads/sec) | 6.0 | | | | | | | |

G*, δ,0.05 to 20 rads/sec, at ([($T_{max}$−$T_{min}$)/2]+4)ºC

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# DSR REPORT – what next?

- Complex modulus, G* [Pa]
- Phase angle, δ [°]
- Frequency, f [Hz] or [rad/sec]
  - Min f = 62.83 Hz (0.05 rad/sec)
  - Max f = 0.314 Hz (20 rad/sec)
- Temperature,T [°C] $\{T_{max}-T_{min})/2\}+4)$
  - PG58-22 22 °C
  - PG64-16 28 °C

Calculate parameters and determine what to do with them

# SARDS and PG SPECS

- Some research work already done under SAPDM (SARDS) project
- Future building of data base

- Link between SARDS and PG Specs essential

# Research requirements

- Collate info from SARDS and other research
- Finalise specification limits
- MSCR – Stress, time (cycles), protocols
- Alternative protocols for durability (fatigue)
- Finalise binder recovery method
- Ageing, especially PAV
- Binder selection, especially for seals
- Develop/define QC and QA on site
- Relate bitumen performance with PG spec
- Where does non-homogeneous binders fit in?
- Binder and asphalt modelling

# Public/private partnership

- SANRAL already sponsored SAPDM
- SABITA sponsored initial research
- Private sector participation
- SANRAL to sponsor research now
  - Direct contribution for project work – R2.5m
  - Bursaries for M-students
- SABITA will contribute through its members
  - Tosas already busy with project (bit rubber)
  - Much in planning stage
- Provinces and Metros?

# THANK YOU