State-of-the-Art Review of Performance Graded Binder Testing using DSR

Working Group on PG Specs, of RPF Binder Spec Committee

RPF at CSIR, Pretoria

19th November 2014

Stellenbosch

THE SOUTH AFRICAN NATIONAL ROADS AGENCY SOC LTD

Reg. No.1998/009584/06

Performance Grading

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




DTT

BBR

DSR

RV

- 20 ^{0}C | 20 ^{0}C | 60 ^{0}C | 135 ^{0}C

Pavement Temperature

STAR report

Institute of Integrated Engineering and Technology

Stellenbosch University

IIET Report 3/ 2014

Performance Graded Binder Classification with Focus on Rheological Testing and Modelling using DSR

Executive Summary of State-of-the-Art Report and Framework for Further Research & Proposal

NOVEMBER 2014

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Introduction of a PG grading system

Introduction

The purpose of this document is to establish a platform for the introduction of a performance grade (PG) system for bituminous binders in South Africa. The process of translation from an industrial grade- to PG system for bituminous binders for road works in SA was given considerable impetus by a symposium, jointly presented by Sabita and the University of Stellenbosch on 29 November 2012 in Stellenbosch. The event gave the SA interest group of 35 delegates the opportunity to interact with two experts from abroad – professor Hussain Bahia, of University of Wisconsin-Madison, who has had extensive involvement in and experience of the development and implementation of the PG system in the USA since 1989 and Martin van de Ven, associate professor of the Technical University of Delft to afford participants an up-to-date perspective of developments in the European Union.

In addition to covering the outcomes of the symposium, this document also elaborates somewhat on the content of the presentations given at the symposium – particularly test procedures aimed at assessing critical performance characteristics – in the interests of clarity and dissemination of the state of affairs to practice, possibly through Sabita's communication facilities and the RPF.

New driving forces in SA

In welcoming delegates to the workshop, Sabita CEO Saied Solomons noted that recent developments such as the impending implementation of the SANRAL sponsored SA Pavement Design Method and the Sabita sponsored revision of a national asphalt mix design method, both of which will be introduced to practice during 2013, necessitated the adoption of a PG system for bituminous binders to ensure optimal performance of flexible pavements, especially in the higher traffic categories. The symposium was an excellent forum in which to evaluate progress made locally with the development of a PG system for SA as well as the current state of affairs related to the PG system in the USA and to learn from the "school fees" paid. In conjunction with the position in the EU, this event afforded delegates the opportunity of a critical examination of the status quo globally to arrive at solutions that will stand SA practice in good stead.

Overview of PG in USA

AGED INDUCED CRACKING CHARACTERISTICS OF BITUMINOUS BINDERS

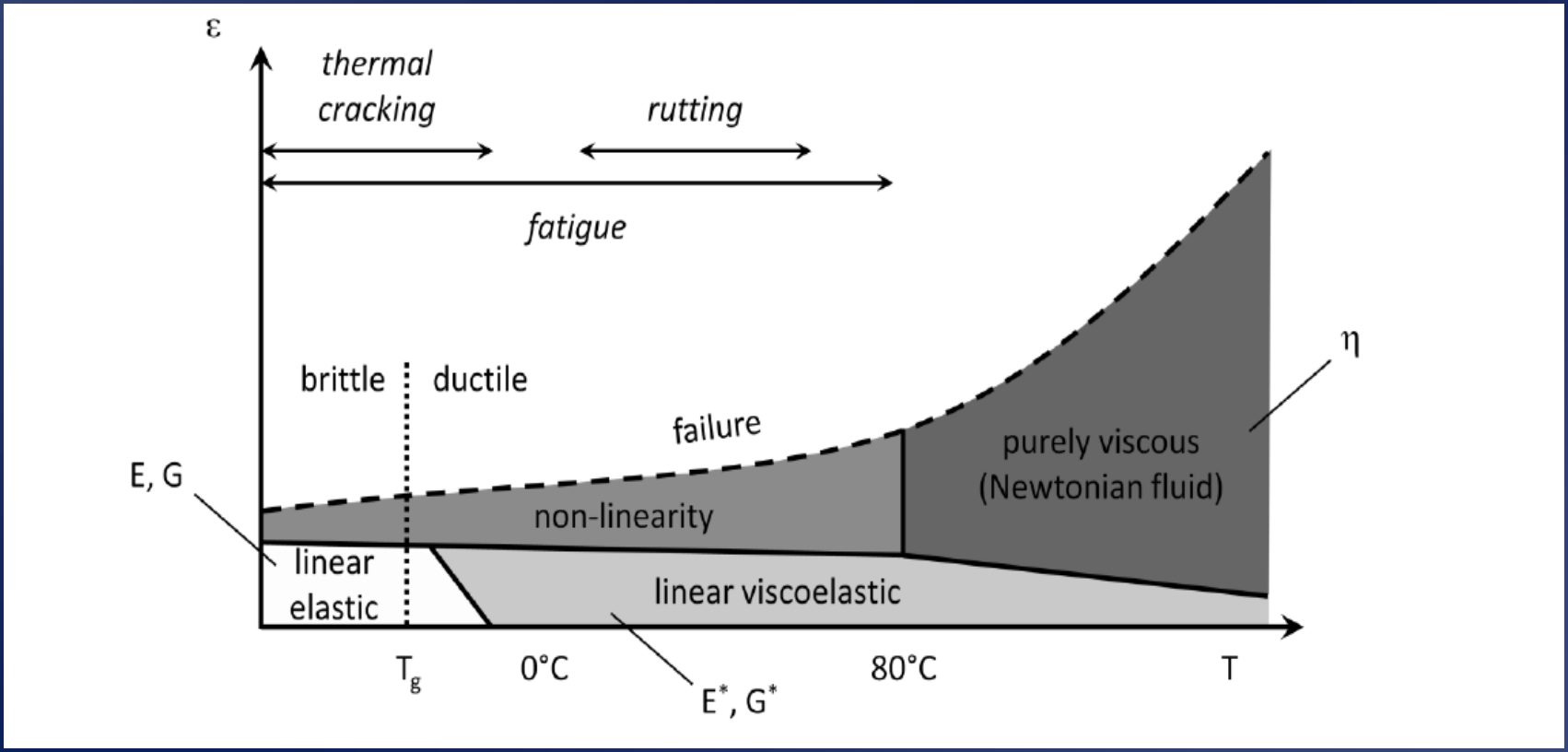
Following a meeting of a lead group representing Sabita (S Solomons, P Myburgh), SANRAL (S Bredenhann), University of Stellenbosch (K Jenkins and M van de Ven) and CSIR (J O'Connell) on the 1st of March 2013, P Myburgh was asked to perform a desk top study on means available to gauge binder properties that would yield satisfactory damage resistance characteristics with respect to fatigue at intermediate temperatures. M van de Ven recommended that the work reported by Glover on behalf of the Texas Transportation Institute & FHWA(2005) and King (RILEM 2012) should be considered. Further information on the suitability of the binder yield energy concept would also be investigated.

This report will cover an appraisal of the findings of the following documents:

1. Report No. FHWA/TX-05/1872-2 – *Development of a New Method for Assessing Asphalt Binder Durability with Field Validation* – Glover et al August 2005
2. 7th RILEM International conference on Cracking in Pavements, Delft, The Netherlands, 20-22 June 2013RILEM 2012 – *Using Black Space Diagrams to Predict Age-induced Cracking* – King et al
3. Transportation Research Circular E-C147: Development in Asphalt Binder Specifications – *Developments in Intermediate Temperature Binder Fatigue Specifications* – Bahia et al
4. Report No.FHWA-HRT-11-045 – *Performance Testing for Superpave and Structural Validation* –Gibson et al, 2012
5. Minutes of the FHWA Asphalt Binder Expert Task Group meeting, September 2010 Madison, Wisconsin
6. Private communication with Hussain Bahia – 13 March 2013

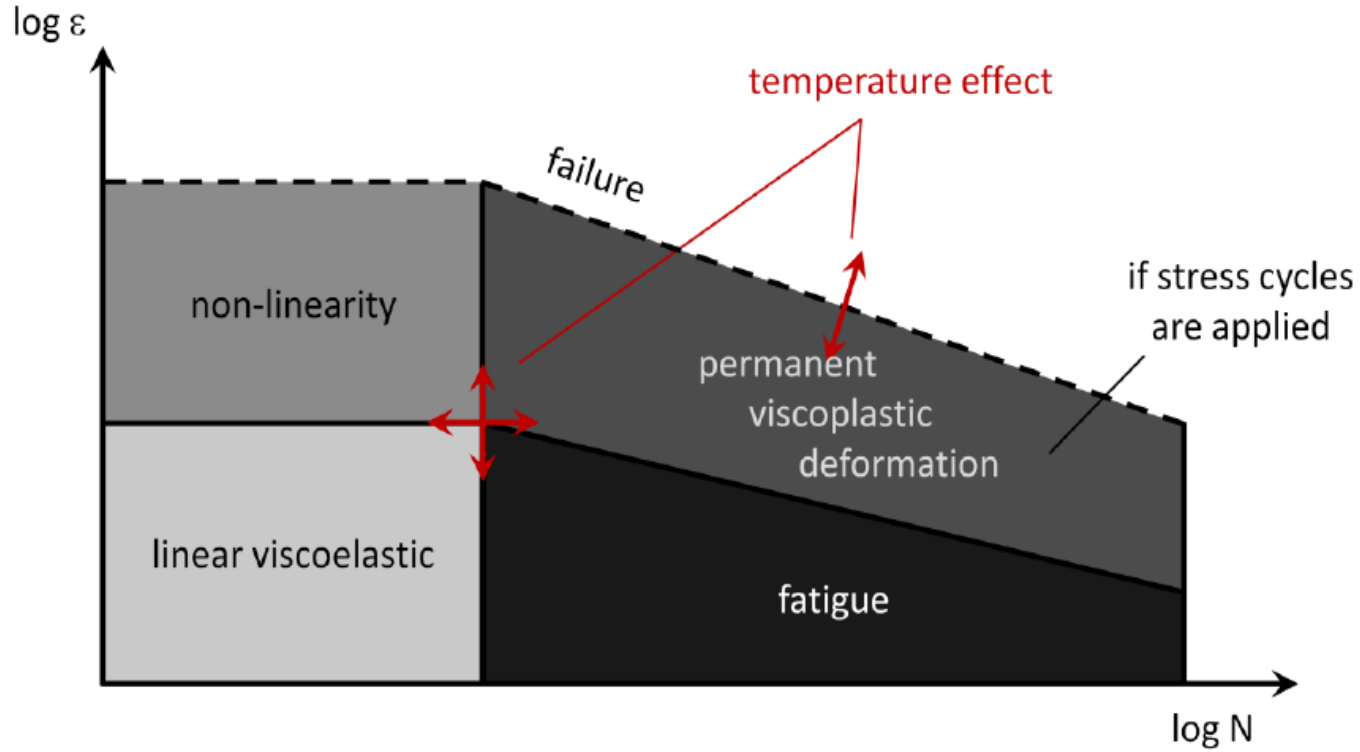
Piet Myburgh, 2013/4

Strain amplitude and Temp influence on bitumen behaviour



Di Benedetto et al, 2014

Strain amplitude and N cycles influence on bitumen behaviour



Di Benedetto et al, 2014

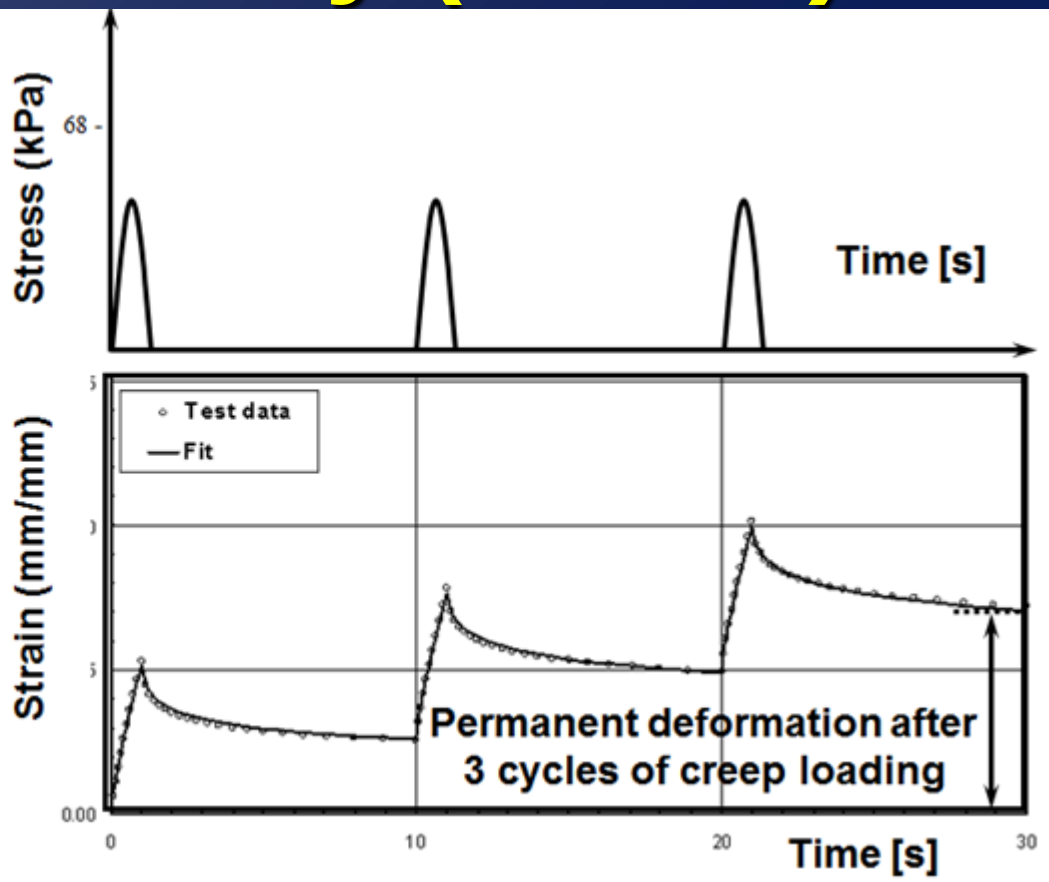
Findings of STAR for Production & Construction$_1$

- Cup-and-bob suited to spraying simulation
- Cone-and-plate suited to mixing simulation
- Further research needed on temperature vs viscosity relationship for different binders
- Need to investigate DSR test configurations for non-homogeneous binders (seals and asphalt)

Primary goal: decide on one high temperature test procedure for PG Classification

The new tests : Creep and Recovery (MSCR)

Repeated Creep Loading



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

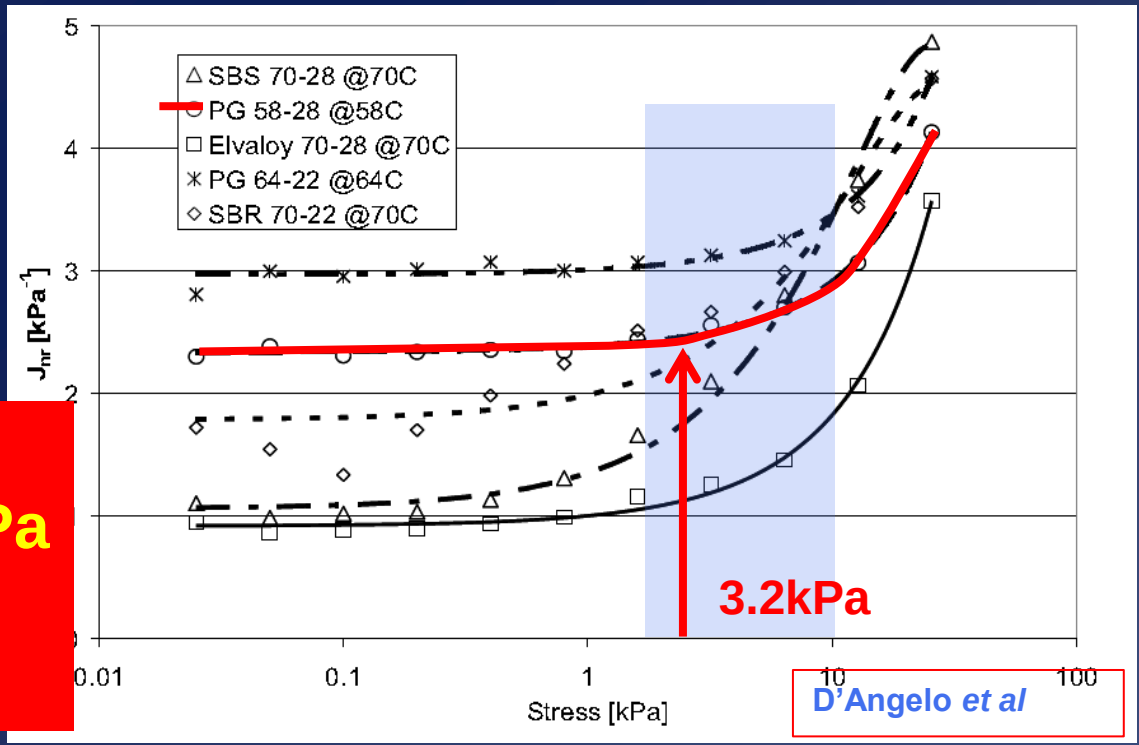
AASHTO TP70

Findings of STAR for $MSCR_2$

- Soenen 2006: binder behaviour is very dependent on thermal history

Nota Bene: sample preparation!!! Fix procedure

- D'Angelo 2007: stress-dependency

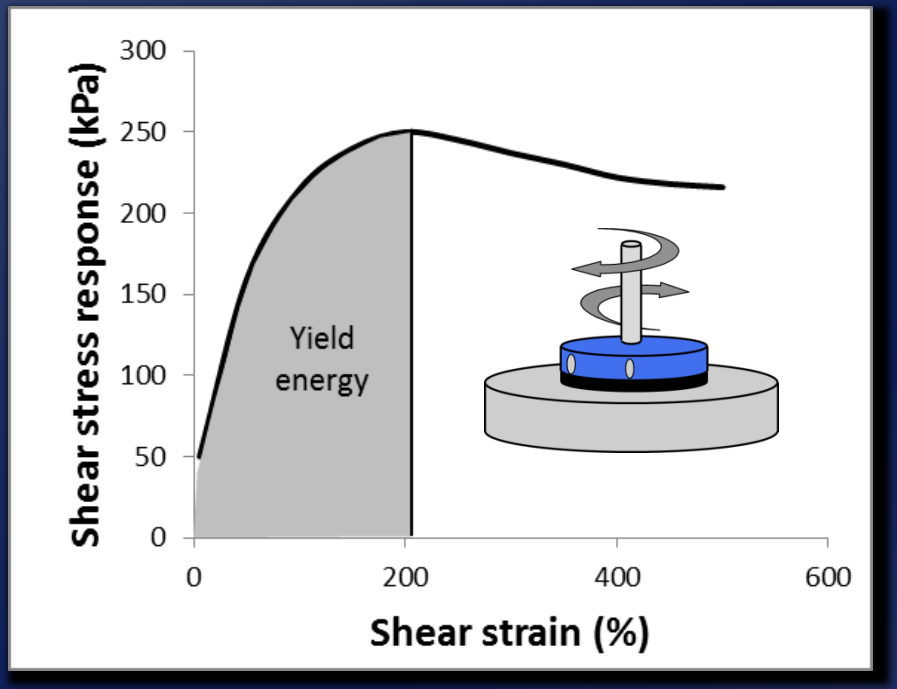


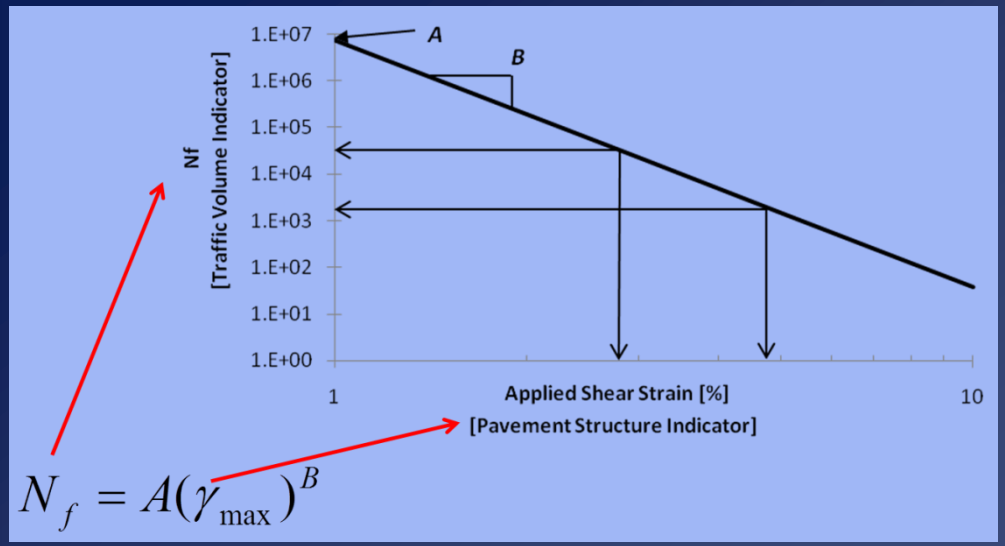
Goal: DSR User Group to investigate t = 3.2kPa & 10kPa for 10 & 50 cycles

Findings STAR on Fatigue$_4$

- **Fatigue on DSR**

BYET versus LAS





Findings of STAR for Fatigue[4]

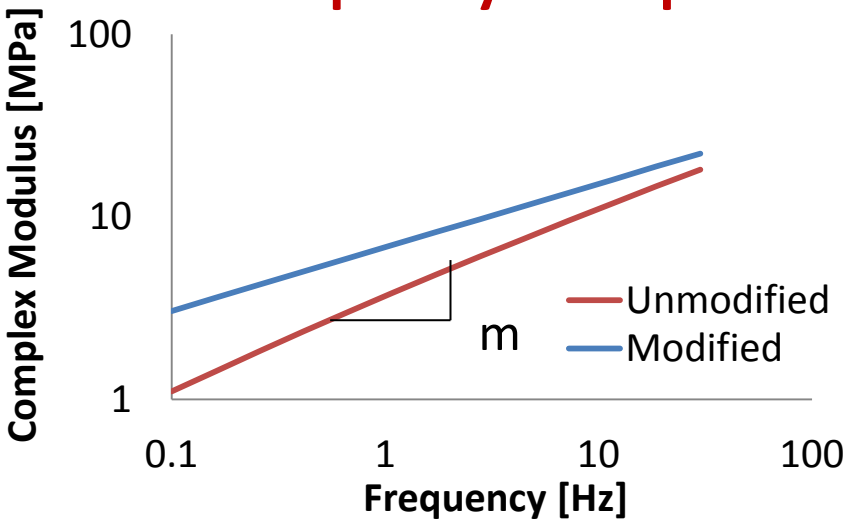
- Hintz 2011: LAS - binder ageing is beneficial to fatigue life for low strain levels (less than 6%) and detrimental at high strain level (above 10%) ie the slope of the fatigue line increases with ageing (RTFO, PAV, 4xPAV)
- Rilem STAR 2013: Need for fatigue evaluation. Protocol developed by Rilem, but requires 9 tests (3 x low, med, high strain) too much testing required!

Many researchers agree: must test the mix for final fatigue analysis!!!

2. Linear Amplitude Sweep

Rheology

Frequency Sweep

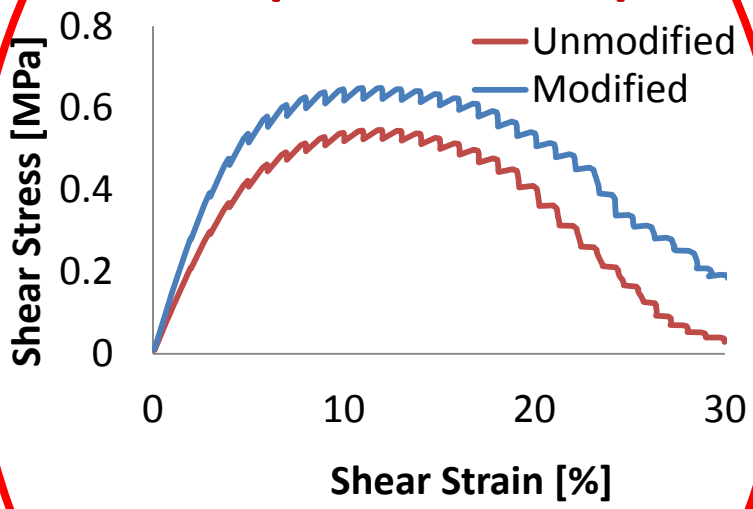


Slope

B

Damage Resistance

Amplitude Sweep



VECD

A

$$N_f = A\,(\gamma_{max})^{B}$$

$LAS_{modified}$: Focus on A = Dynamic Yield Energy Parameter, shorter test

(Bahia, 2014)

Findings of STAR for LT Cracking$_5$

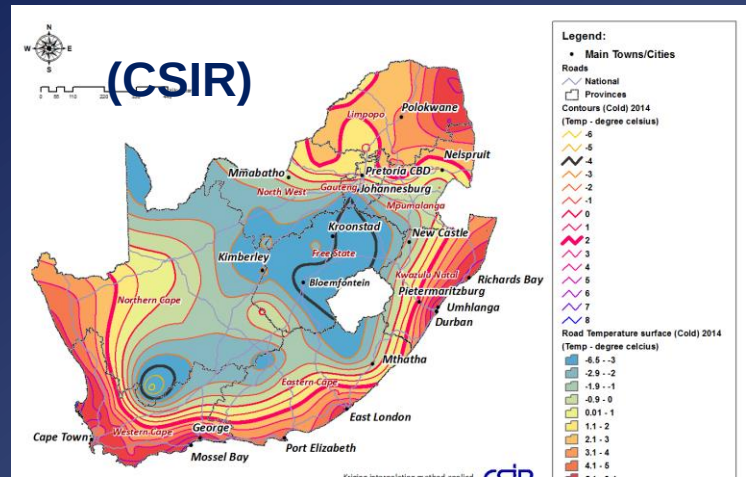
- **Three distress mechanisms to be considered**
  - **Single event temperature cracking (SETC)**
  - **Thermal fatigue (TF)**
  - **Load associated thermal fatigue (LATF)**

Findings: One can't test every mechanism.
Selection of ONE test method is important

Previous: PG Spec Research$_5$

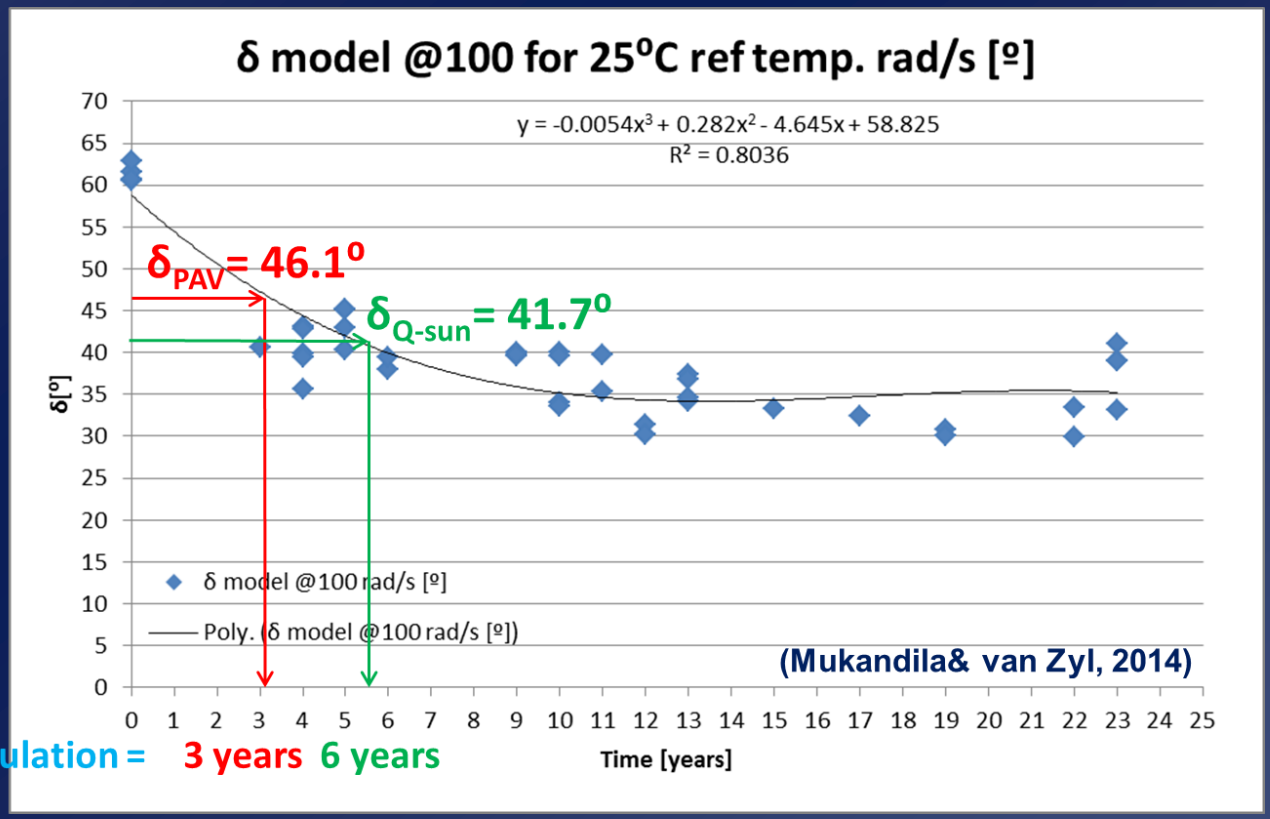
- **Low Temperature LT Cracking with DSR**
  - Tests in SA originally done at -16C to date
  - Blanket suggestion on LT at -10C for SA (although non-standard, it could be adopted)
  - Creep test @ 5ºC preferred (for s & m)
  - More research in SA, as UWM used cyclic load
  - CSIR method to investigate tand method of Soleimani and Hesp

Most of these proposals are still applicable. Test temps & load signals require further research



Previous Research: Binder Ageing$_6$

- Long Term Ageing Simulation
  - Standard PAV hopelessly underestimates field ageing e.g. 3 years equivalent not 10 yrs



Findings of STAR for Ageing$_6$

- Glover 2005: film = 0.86mm @ 90ºC 20 atmph extended to 36 hrs
- Glover 2014: Rate of ageing of binder is all about diffusivity (not so much void structure). Personal comm – kinetics of ageing are compromised by thinner films, 2005 method was empirically based. Stick to 1/8” (3.2mm)

New decision Nov 2014: Follow standard PAV, even though it has empirical links to field ageing

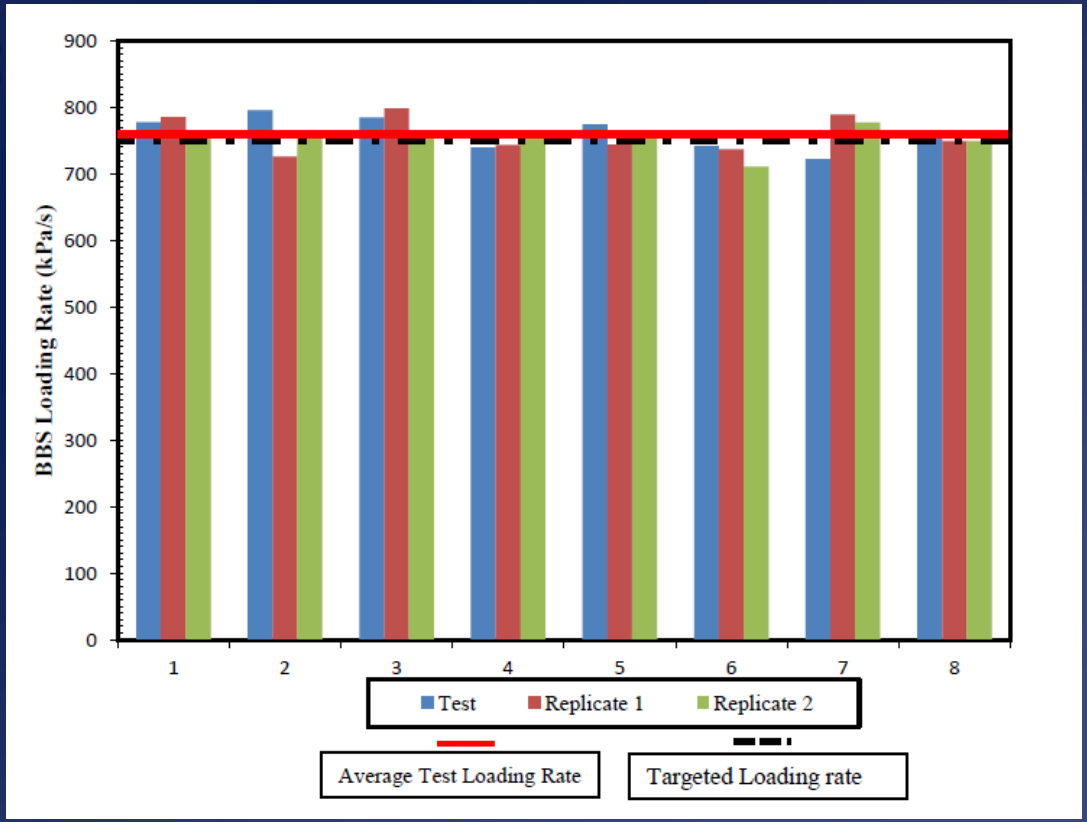
Findings of STAR on Binder Recovery$_7$

- **Binder recovery from STAR**
  - Peterson 2000: recovery of RA binders. AI method using n-Propyl-Bromide solvent
- **Binder recovery previously reported**
  - Abson method (CSIR) and Rotor Vapour Method (CSIR +other labs). NCHRP paper.
  - Report by Georges Mturi
    - Centrifuge – how many repeats?
    - FTIR or another method to check if filler is out
  - **Standardise Rotor Vapour for SA** (Georges, Hennie, Herman, Wynand)

Findings of STAR on Adhesion[8]

- Huurman 2010: DSR adhesion test on very thin binder films between stone columns
- Jenkins 2013: Synthesis of BBS test research
- Twagirimana 2014: compressor capacity is vital to ensure consistent loading rate

BBS remains suited for std evaluation of engineering properties but NOT spec test



Way Forward for 2015

- Original research initiatives identified by WG to date, should be pursued
- New details from STAR need to be taken cognisance of
- Proposal prepared for SANRAL
  - Research needs identified from STAR to address GAPS (in // with DSR Users)
  - Budget for Northern and Southern Research Groups to be motivated


Thank you!!