SAPDM
SEAL PERFORMANCE

Road Pavement Forum May 2015

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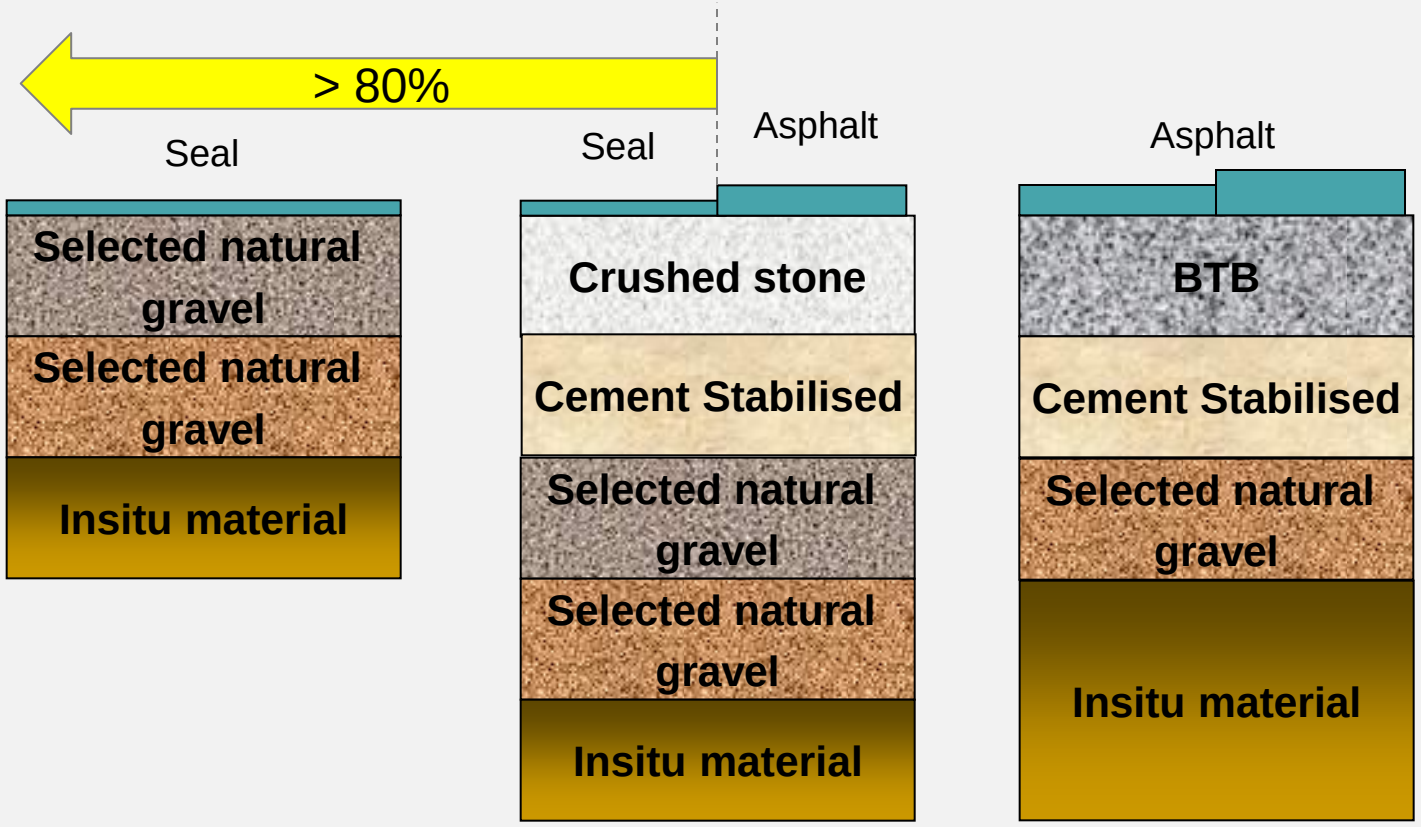
Scope

- Seals in the South African environment
- Purpose of this study
- Recap: Information shared at previous RPF
- Work done since then
- Current activities

Seals in South Africa

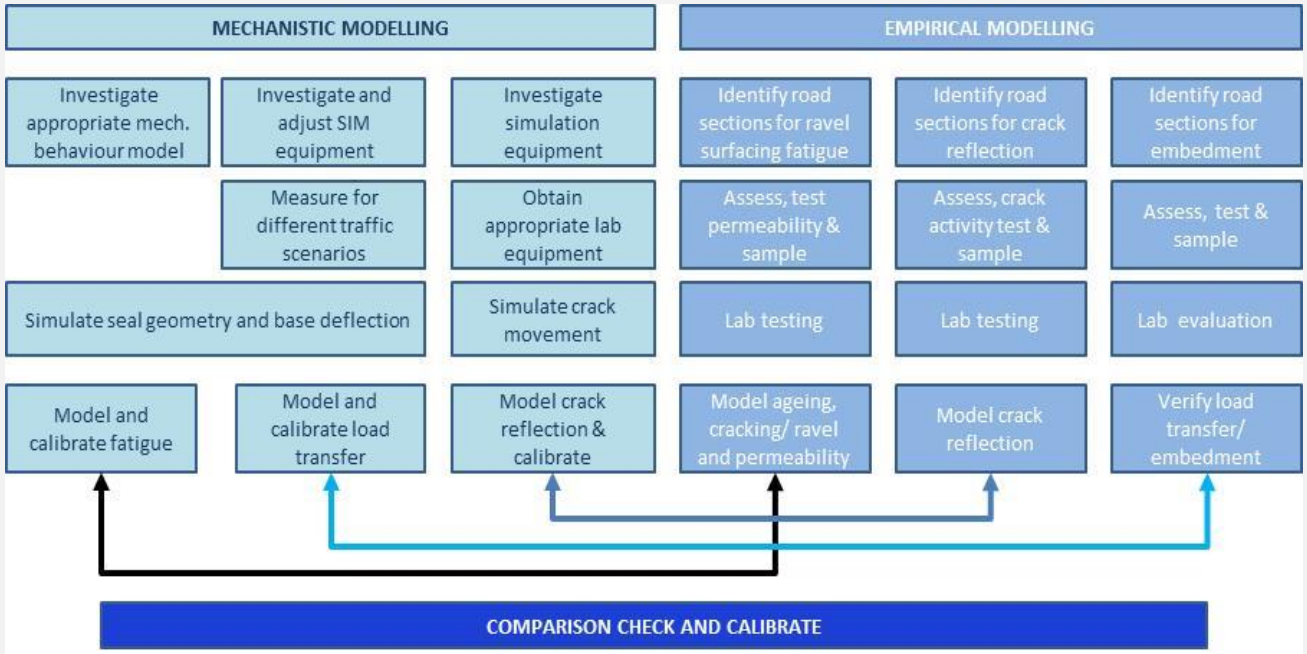


Purpose of this study component

- **Understand seal performance**
- **Impact on pavement performance**
- **Model pavement performance (System)**

- **Select optimum measures (Asset preservation)**
- **Develop more scientific Seal Design Method**
  - Correct type and sufficient binder
    - Prevent early stripping (Adhesion loss)
    - Prolong crack initiation (Cohesion)
    - Maximise texture retention
- **Provide tools to investigate new products**

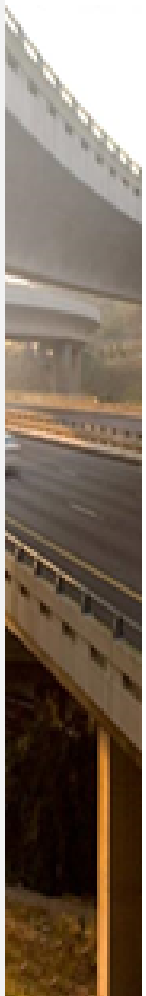
Empirical modelling



Empirical and Mechanistic Modelilng :

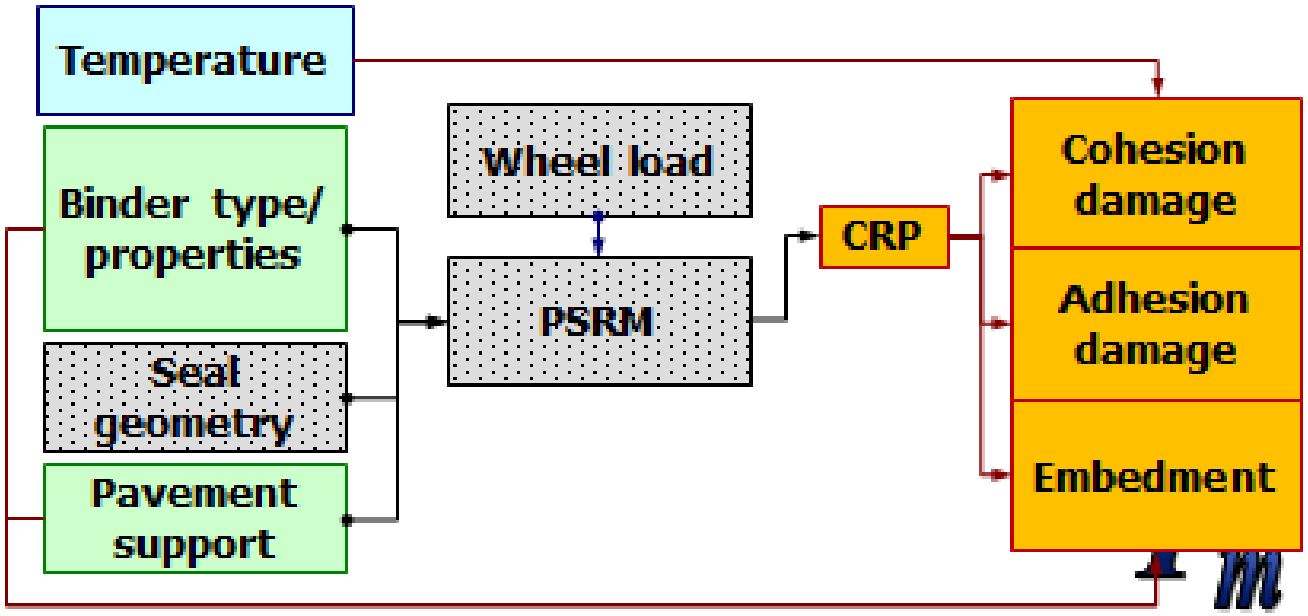
- Binder ageing and cracking (Cohesion)
- Stripping (Adhesion)
- Texture loss

Responsibilities

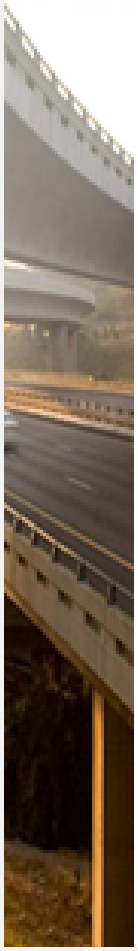


Seal Damage Models

- Calculates the irreversible damage of the seal under loading
  - Estimé and Johan must produce the data for this
  - Special formulation required

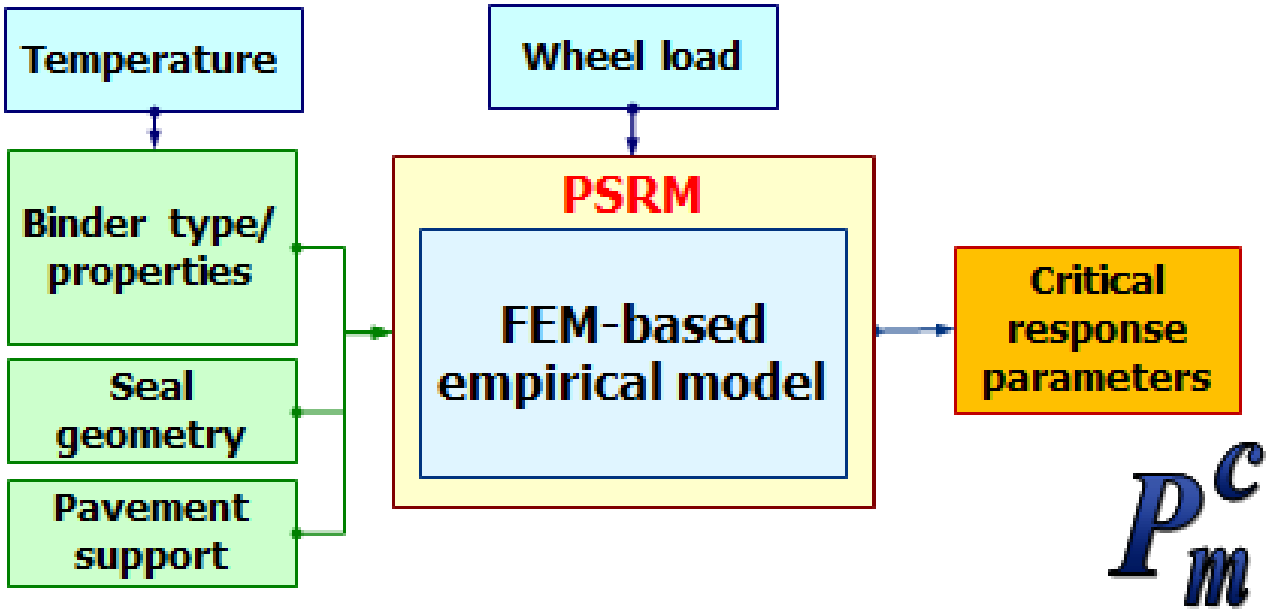


Responsibilities



Primary Seal Response Model

- Calculates the immediate stress and strain response of the seal to loading
  - This is what Johan should develop



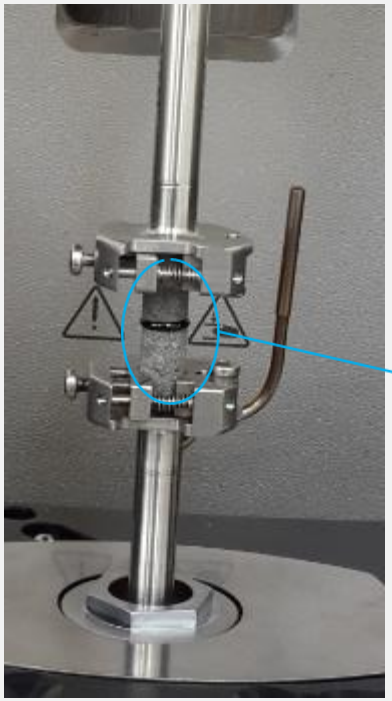
Responsibilities

- **Gerrie to develop new or calibrate existing models for:**
  - Crack initiation/ reflection/retardation
  - Adhesion
  - Loss of macro texture

Shared at previous RPF

E Mulandila

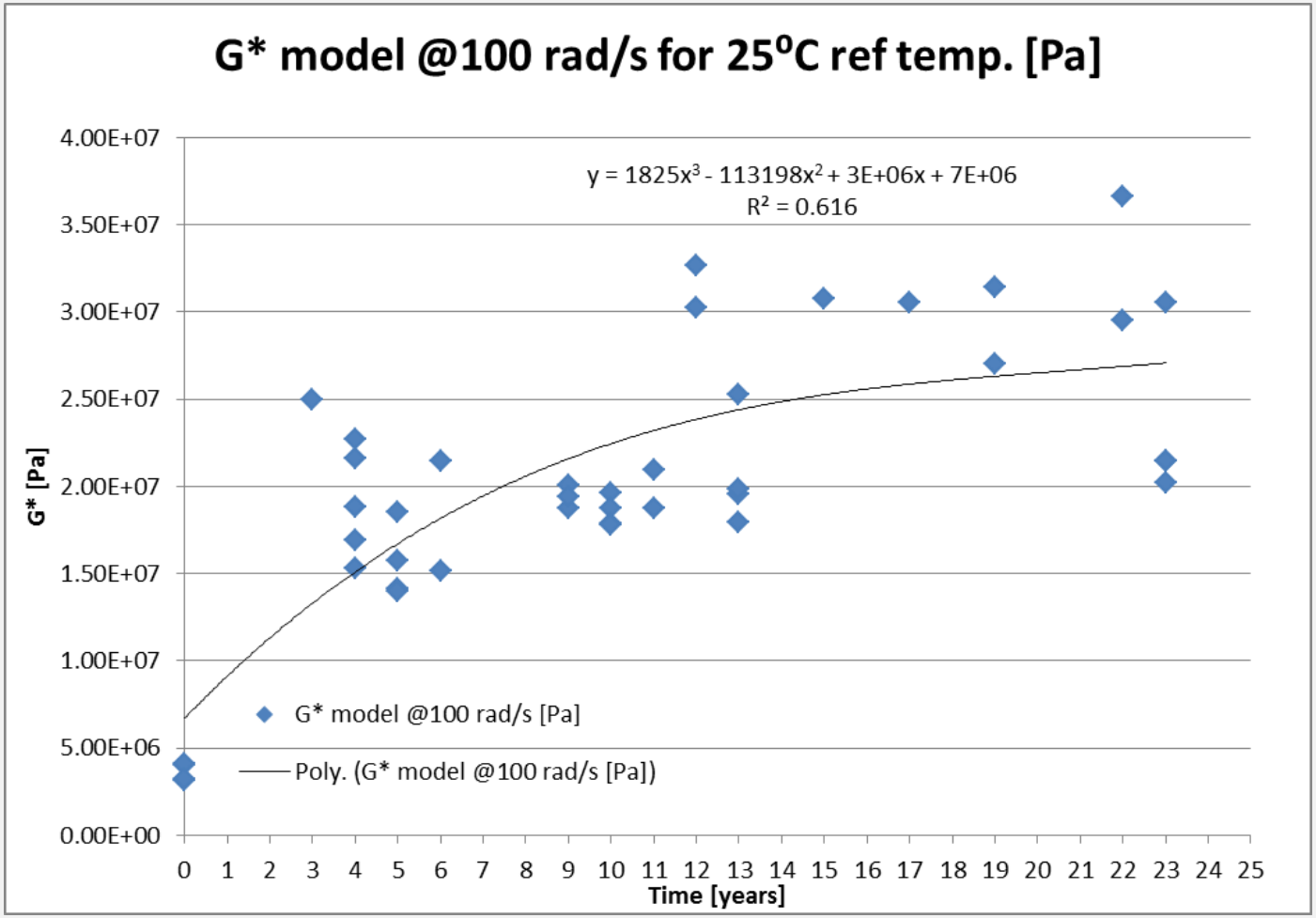
- **Testing protocol e.g.**
  - DSR Clamping configuration for Stone-binder adhesion zone test



Done in strain controlled.

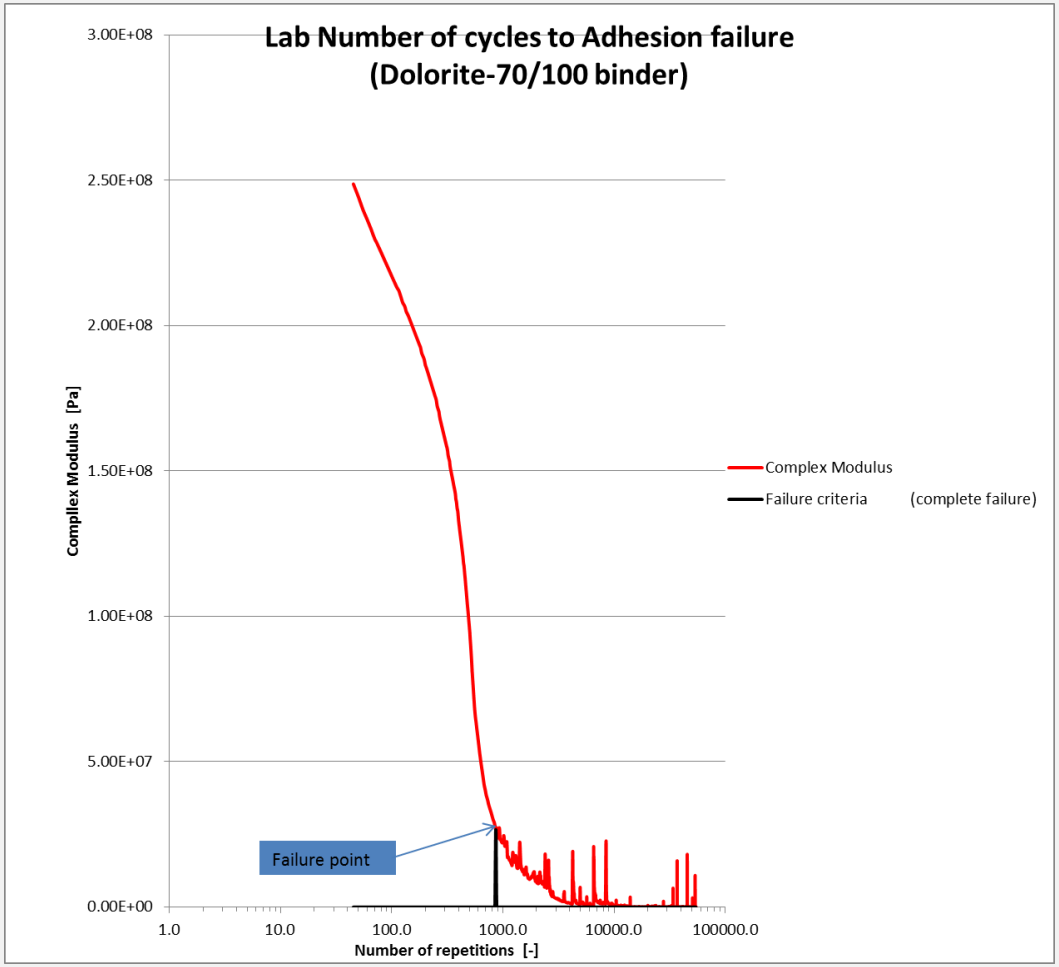
E Mulandila

- **G* Ageing model**



Adhesion Model Stone-binder adhesion zone

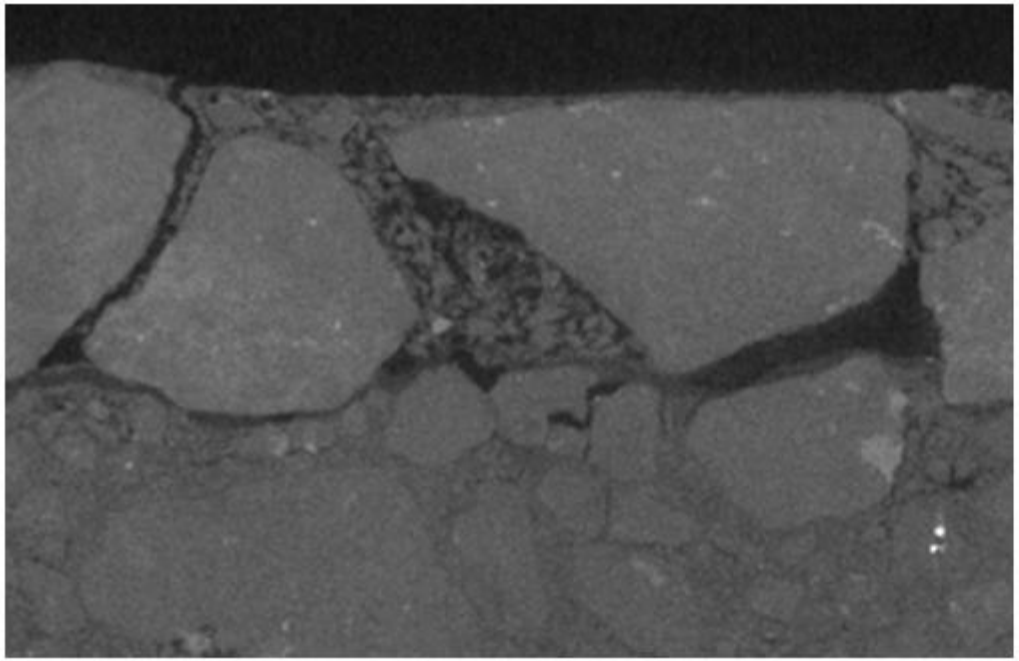
- Adhesion model
  - Output Fatigue graph using Cumulative Damage Principal

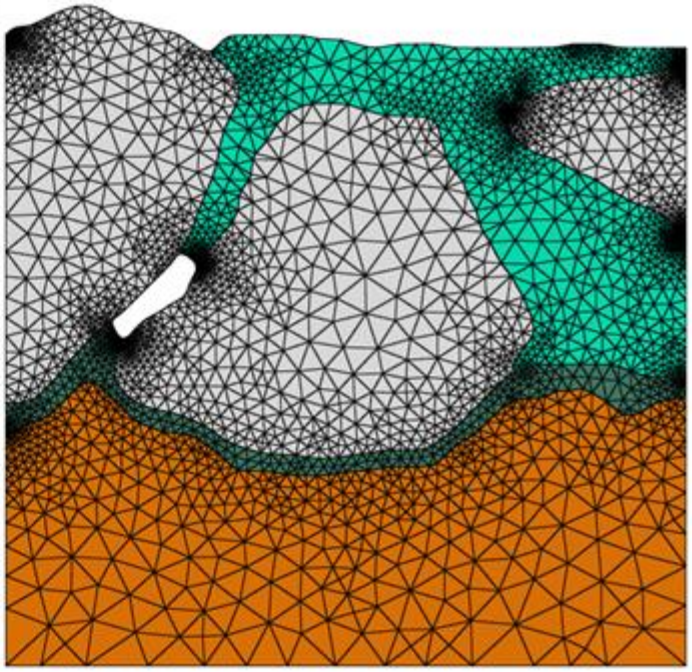


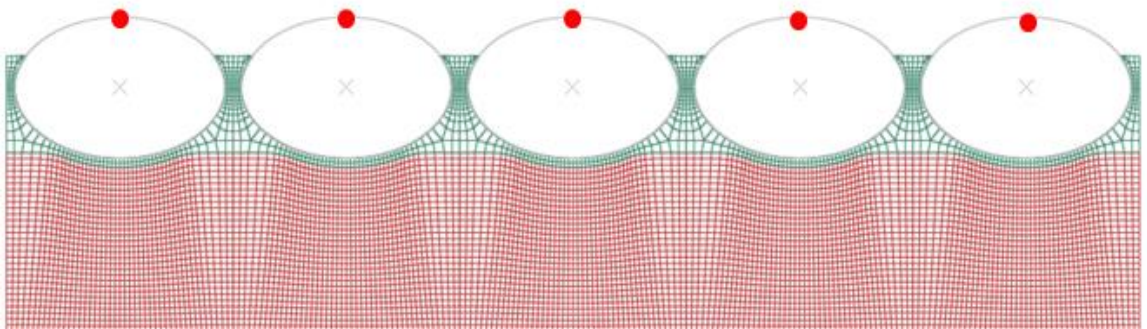
$$N_f = \frac{1}{\left(\frac{\sigma_{et}}{\sigma_0}\right)^{n_0}}$$

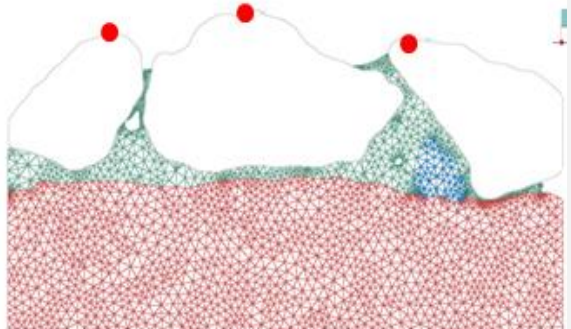
J Gerber

- **Set up of the FEM and complexities**





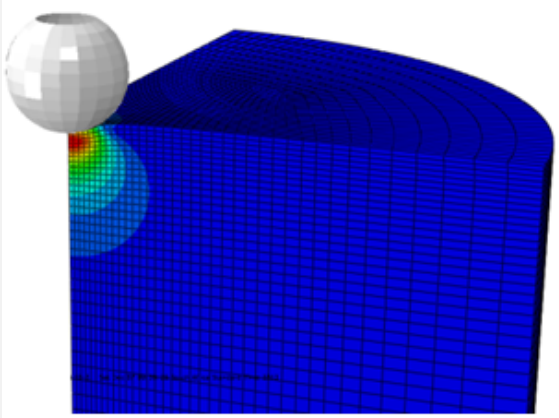


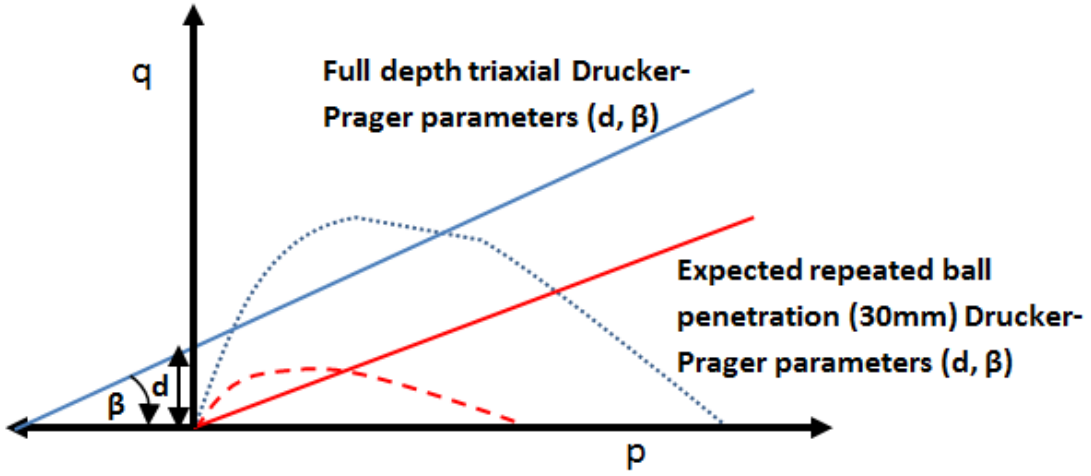


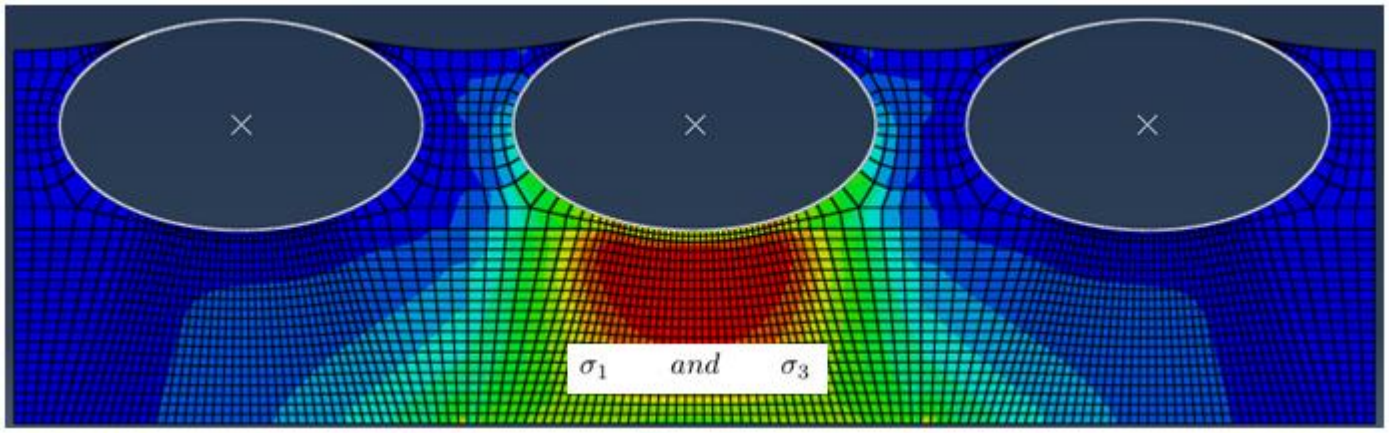
J Gerber

- **Variables incorporated in analyses**
  - Adhesion failure
  - Cohesion failure
  - Embedment
- **Principles applied**
- **Some results**

J Gerber

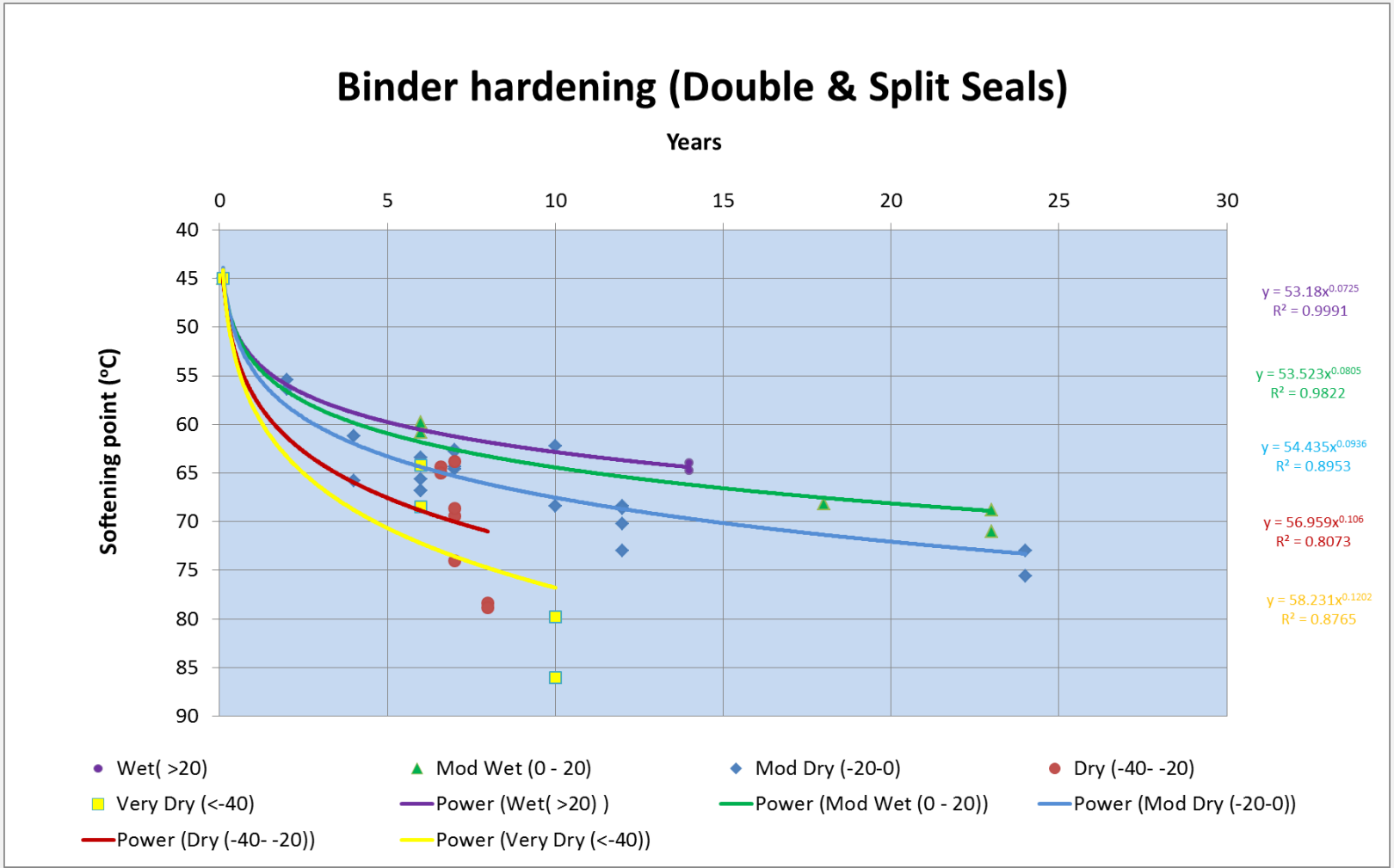



q
Full depth triaxial Drucker-Prager parameters (d, β)
Expected repeated ball penetration (30mm) Drucker-Prager parameters (d, β)
β
d
p


σ_1 and σ_3

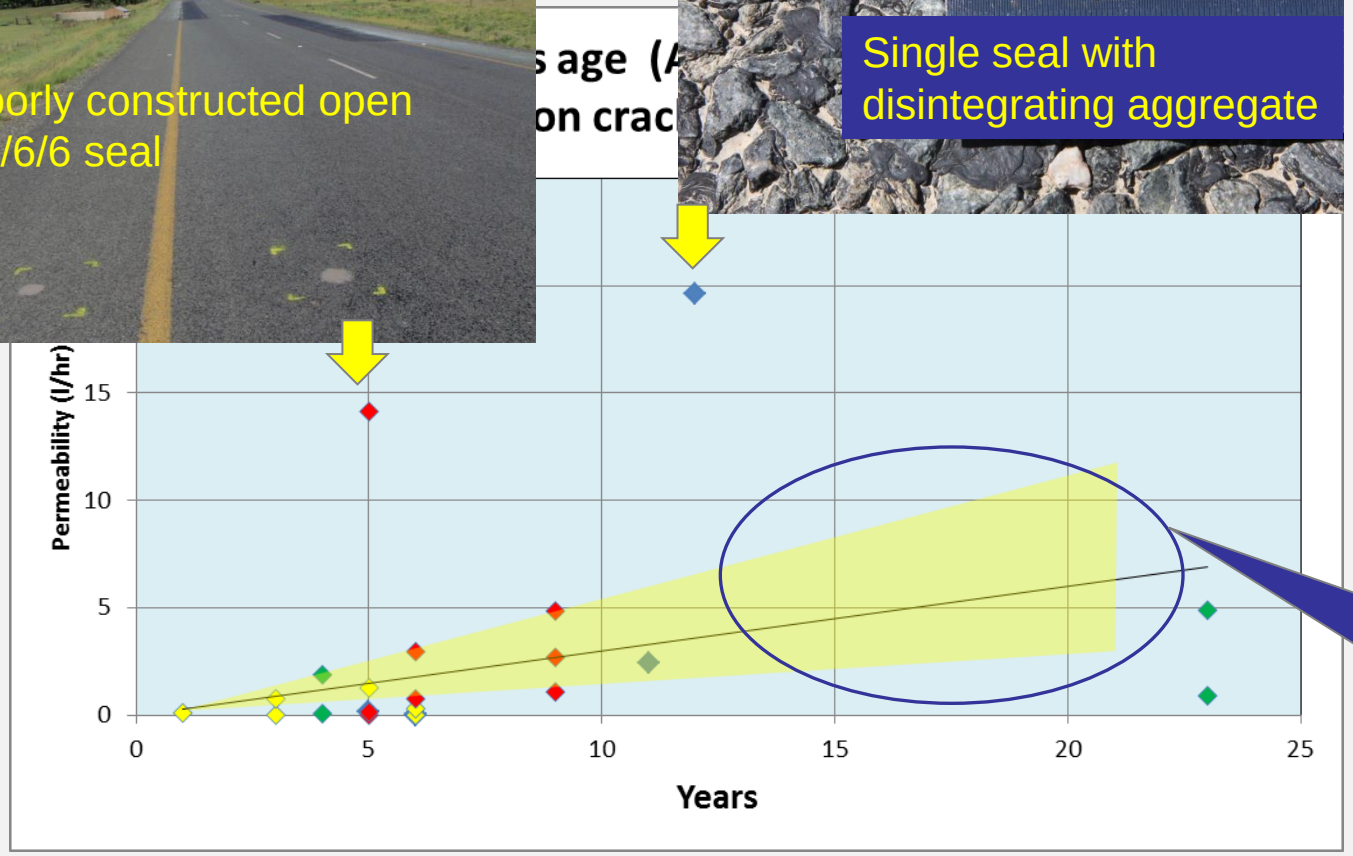
G van Zyl

- **Age-hardening**



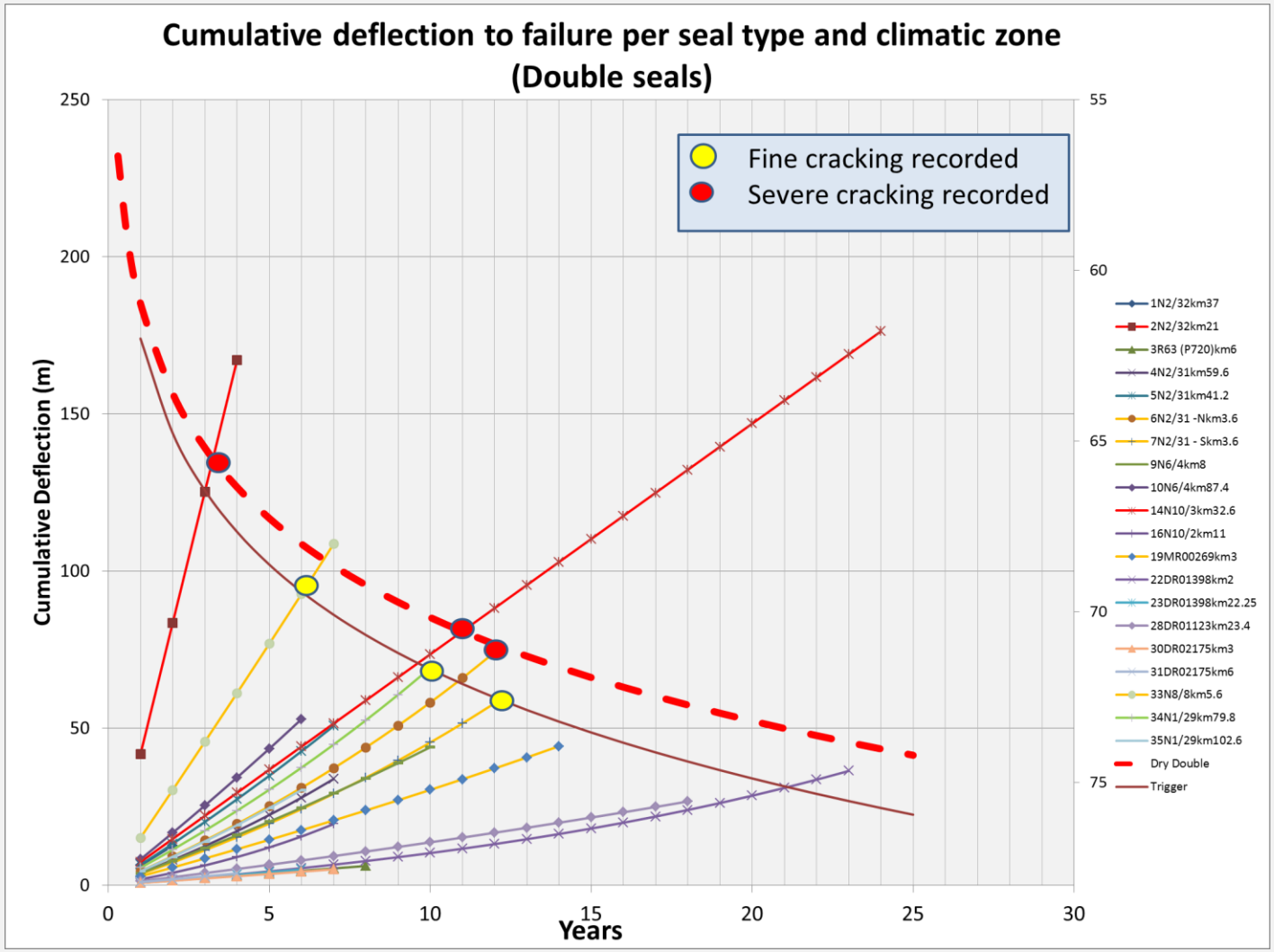
G van Zyl

- **Increase in perm**



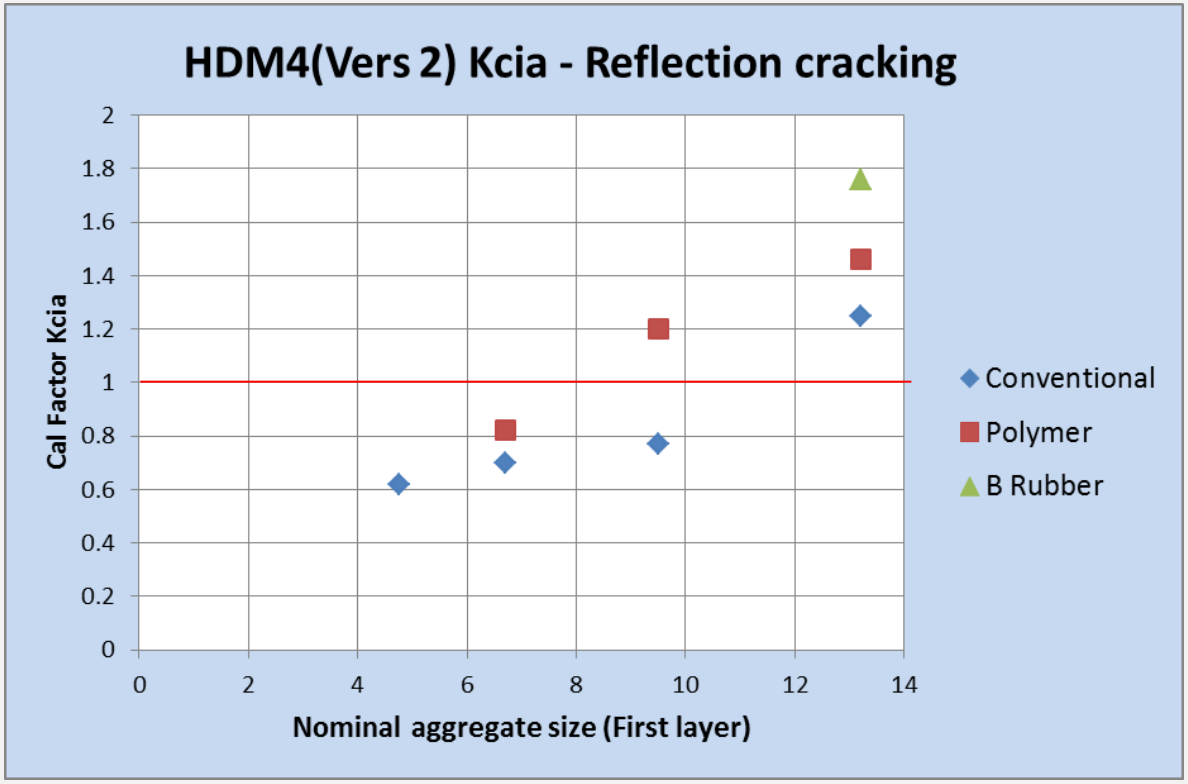
G van Zyl

- **Provisional models for crack initiation**



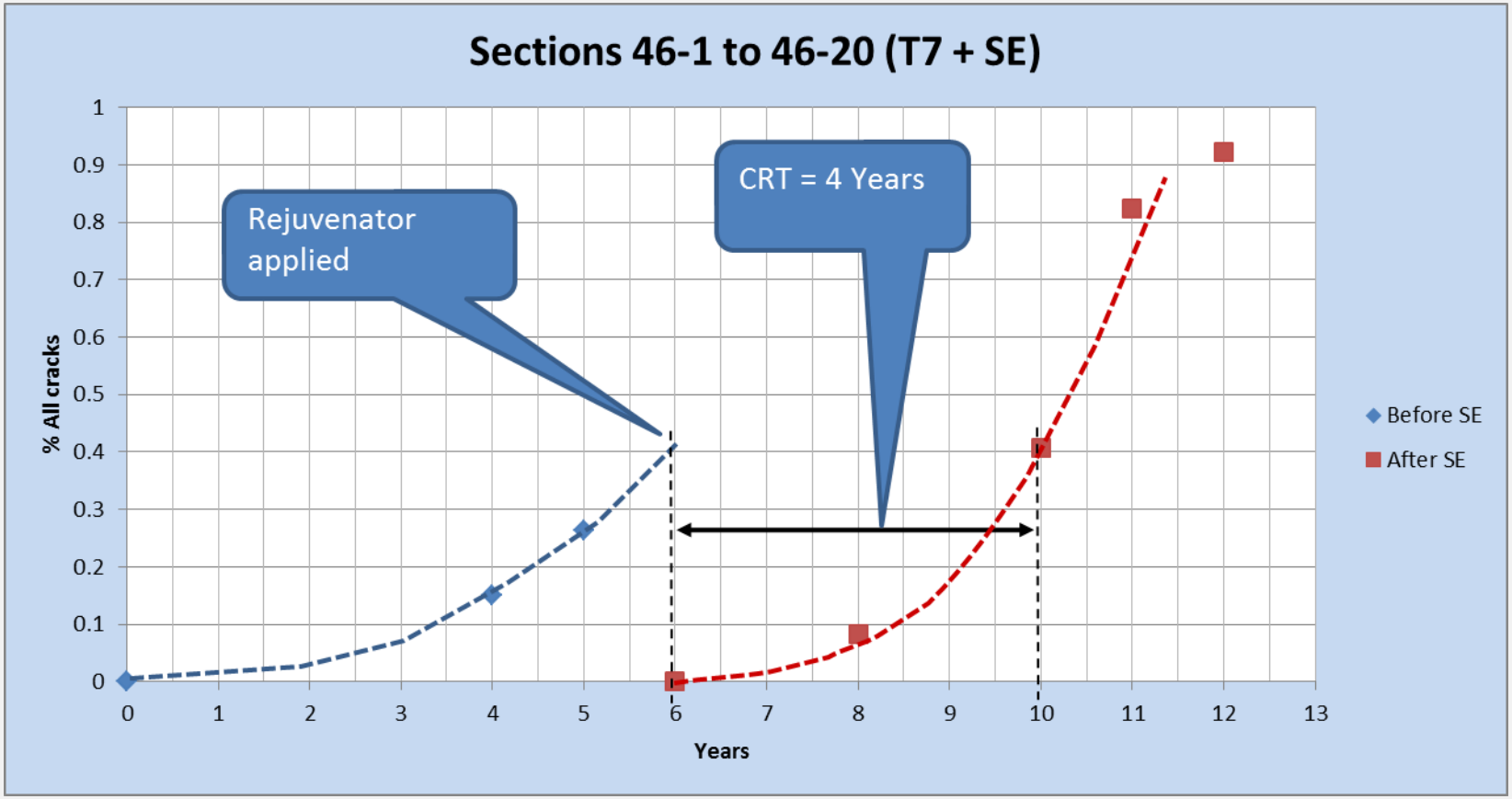
G van Zyl

- **Quantified effect of film thickness and binder type on crack reflection**



G van Zyl

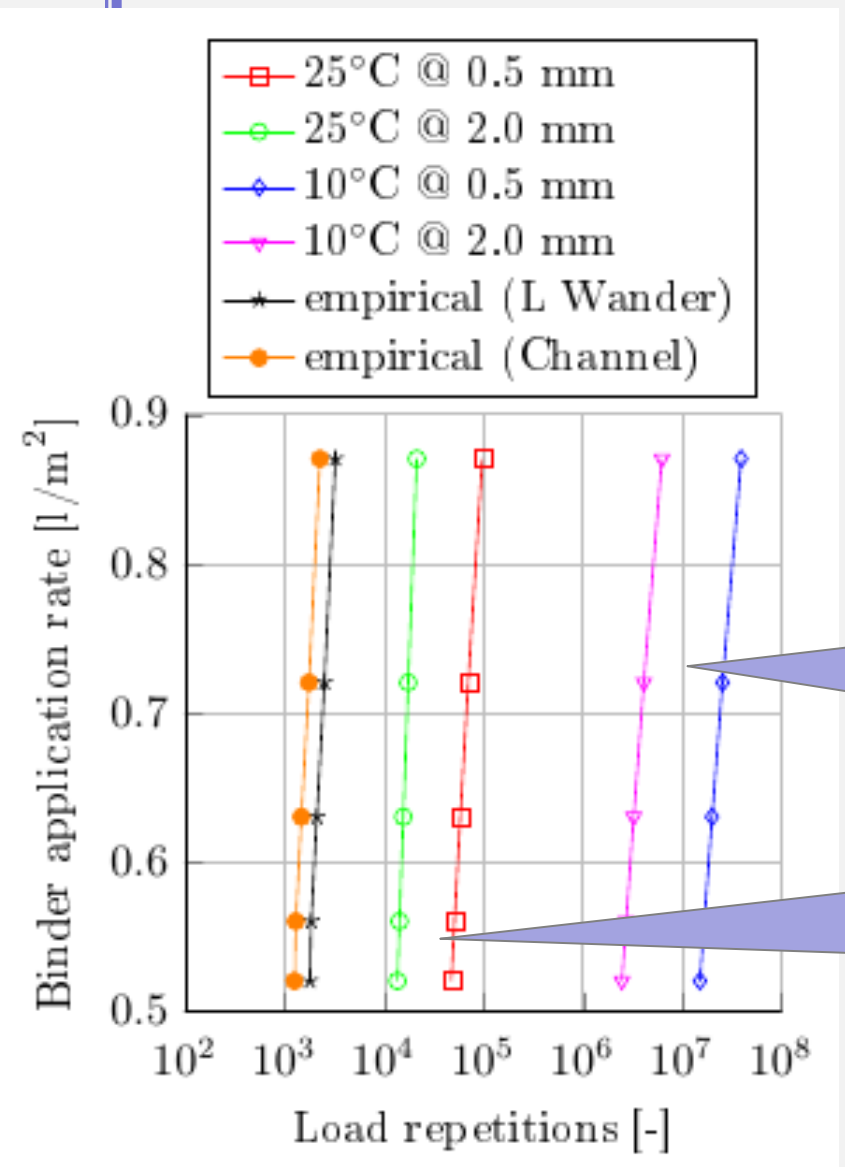
- **Crack retardation**



Work since then

- **Van Zyl**
  - Texture loss model
  - Investigating alternative model forms
- **Gerber & Mukandila**
  - Mechanistic modelling, adjustment, calibration
- **Team**
  - Sanity checks and adjustments

Sanity Checks



- **Anomalies found**
  - E.g Adhesion failure

Colder binder = less risk of stripping (incorrect)

Closer spacing of aggregate = less risk of stripping (correct)

Back tracking

- **Several possible reasons – to be resolved**

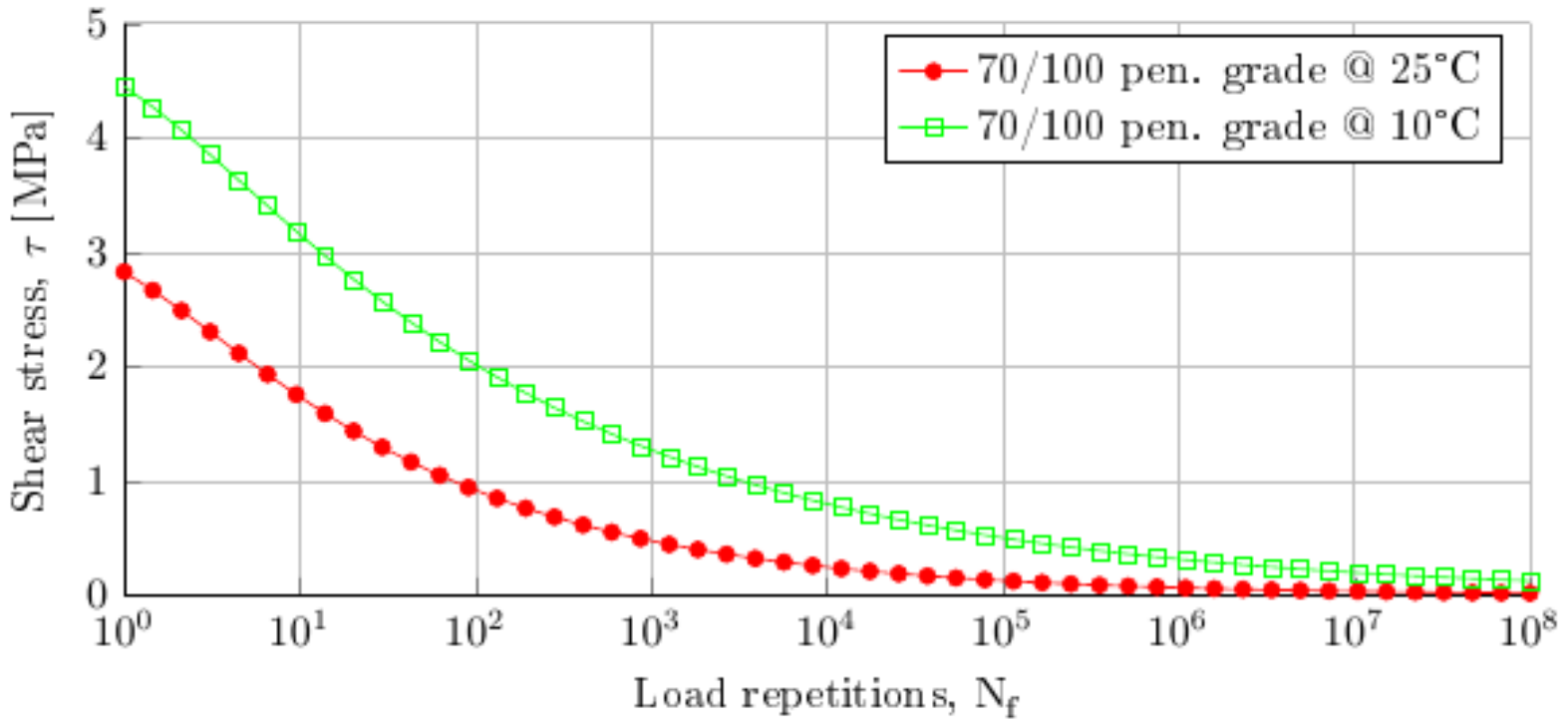


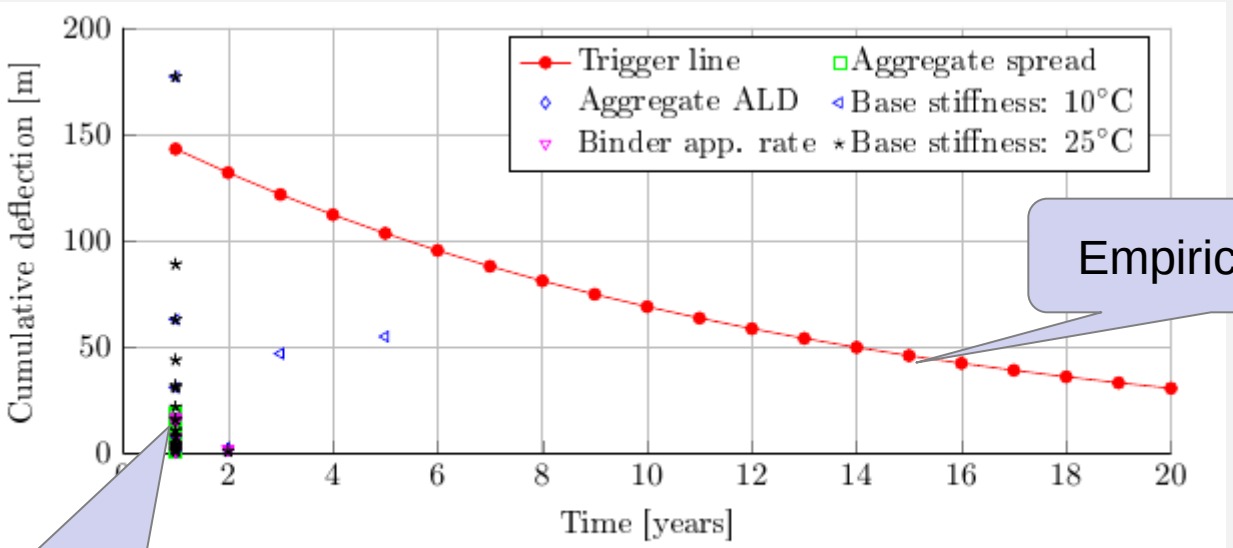
Figure 2.3: Adhesive fatigue transfer functions for virgin 70/100 penetration grade binder (Mukandila, 2015).

FEM Calibration

- **Crack initiation – initial outcome**

Table 4.2: Cohesive failure validation traffic volumes and growth rates.

Regions	Traffic volume description	Number of E80s/day/lane	Annual growth rate i [%]
Region 1	High	600–300	1, 3, 5
Region 2	Moderate	300–150	1, 3, 5
Region 3	Low	150–38	1, 3, 5



2: Cumulative deflection and time of cohesive fatigue cracking.

Empirical model

Rapid failure FE model

FEM Calibration - Cracking

- **Adjustment applied for:**
  - Healing (Rest period)
  - Wander
- **DELFT adjustments for Asphalt as guide**

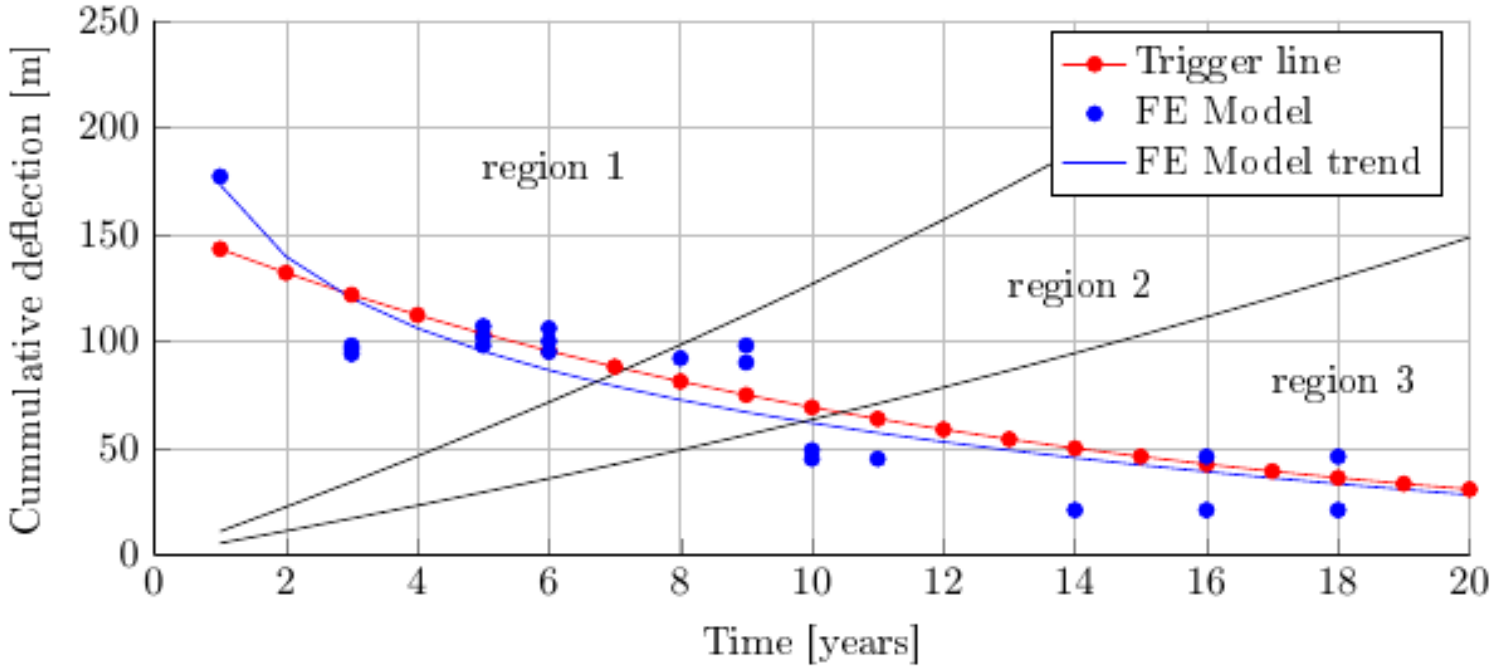


Figure 4.23: Cumulative deflection and adjusted time of cohesive fatigue cracking.

Loss of Macro Texure

Embedment

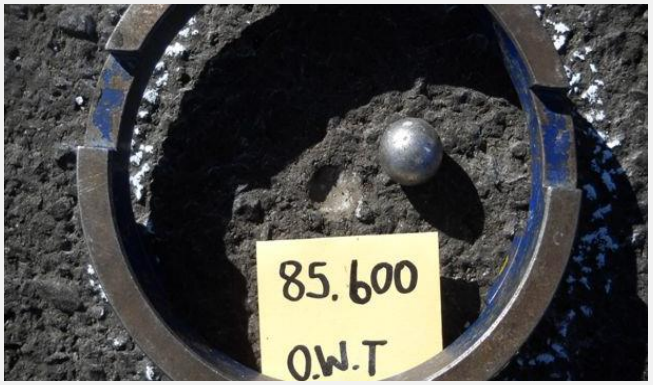
Orientation

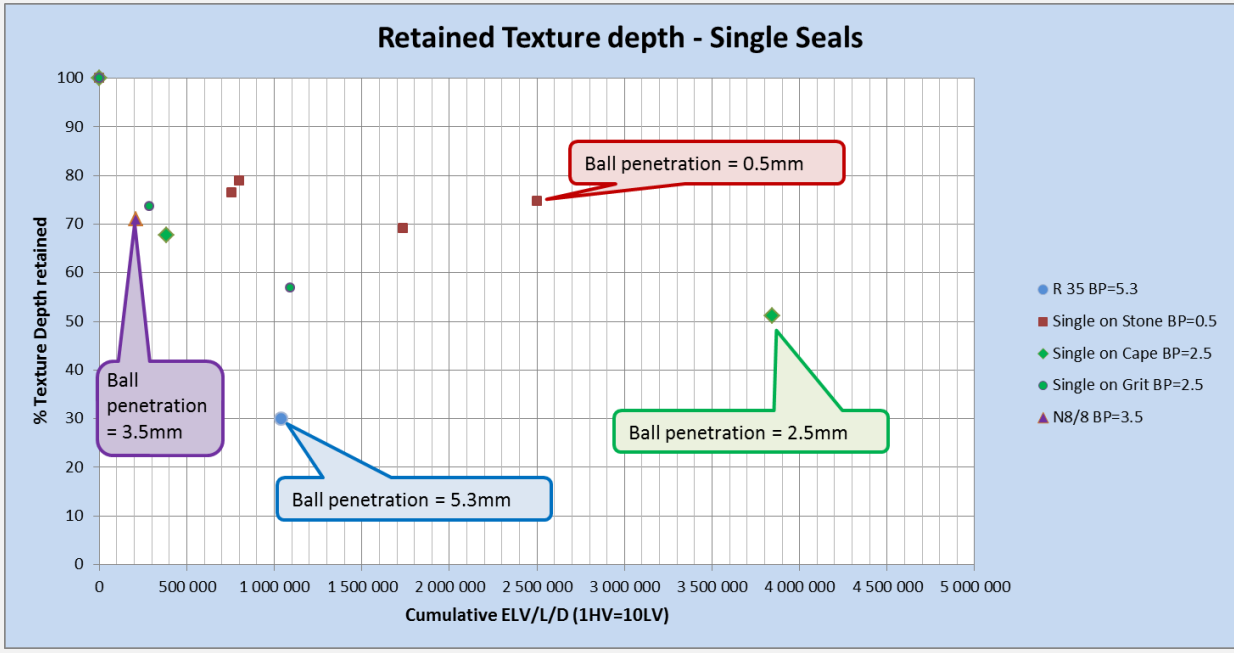
Aggregate wear

Binder rise

Loss of Macro Texture

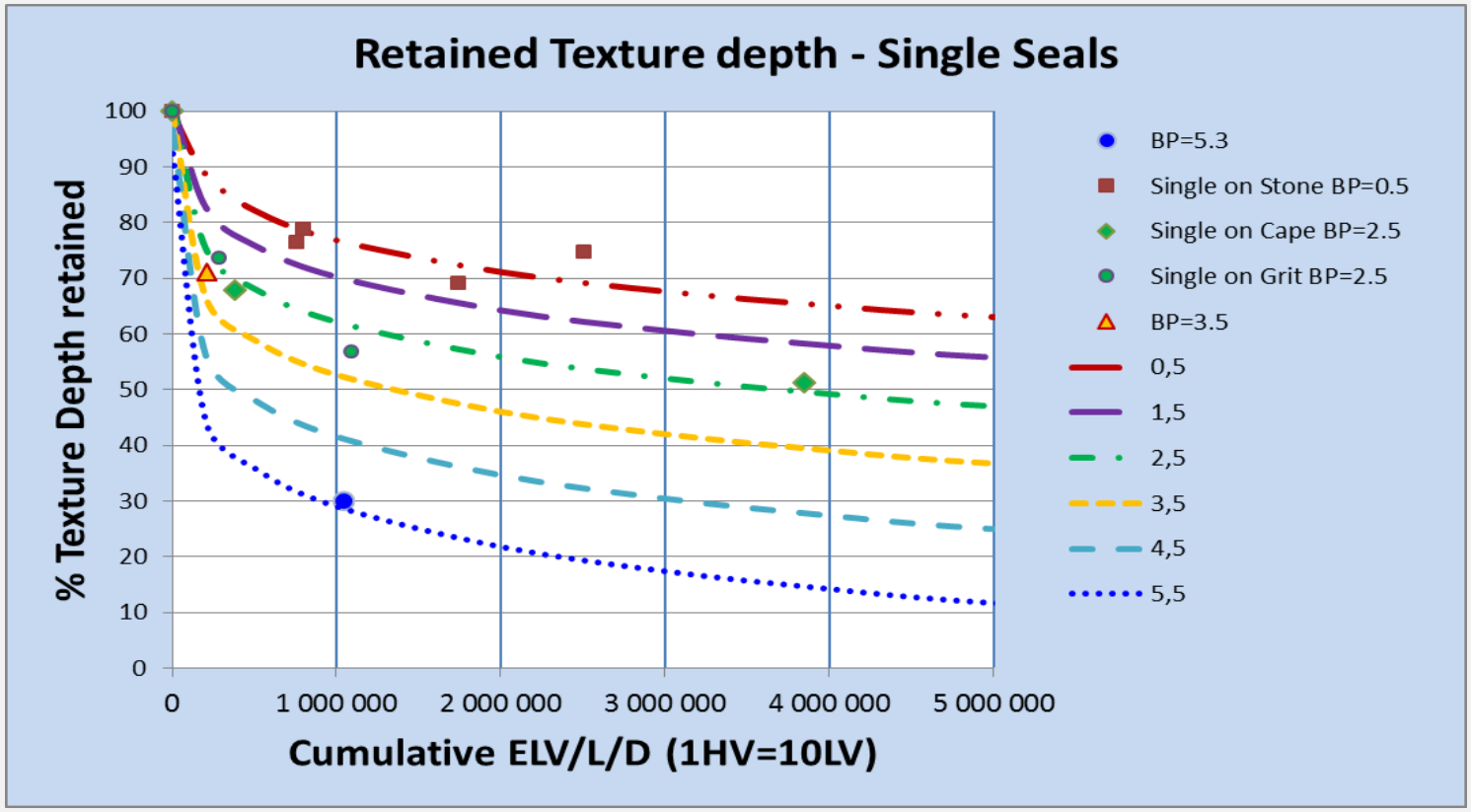
- **International models ?**
- **RSA - Function of:**
  - Seal type (structure)
  - Substrate softness
  - Construction
  - Traffic





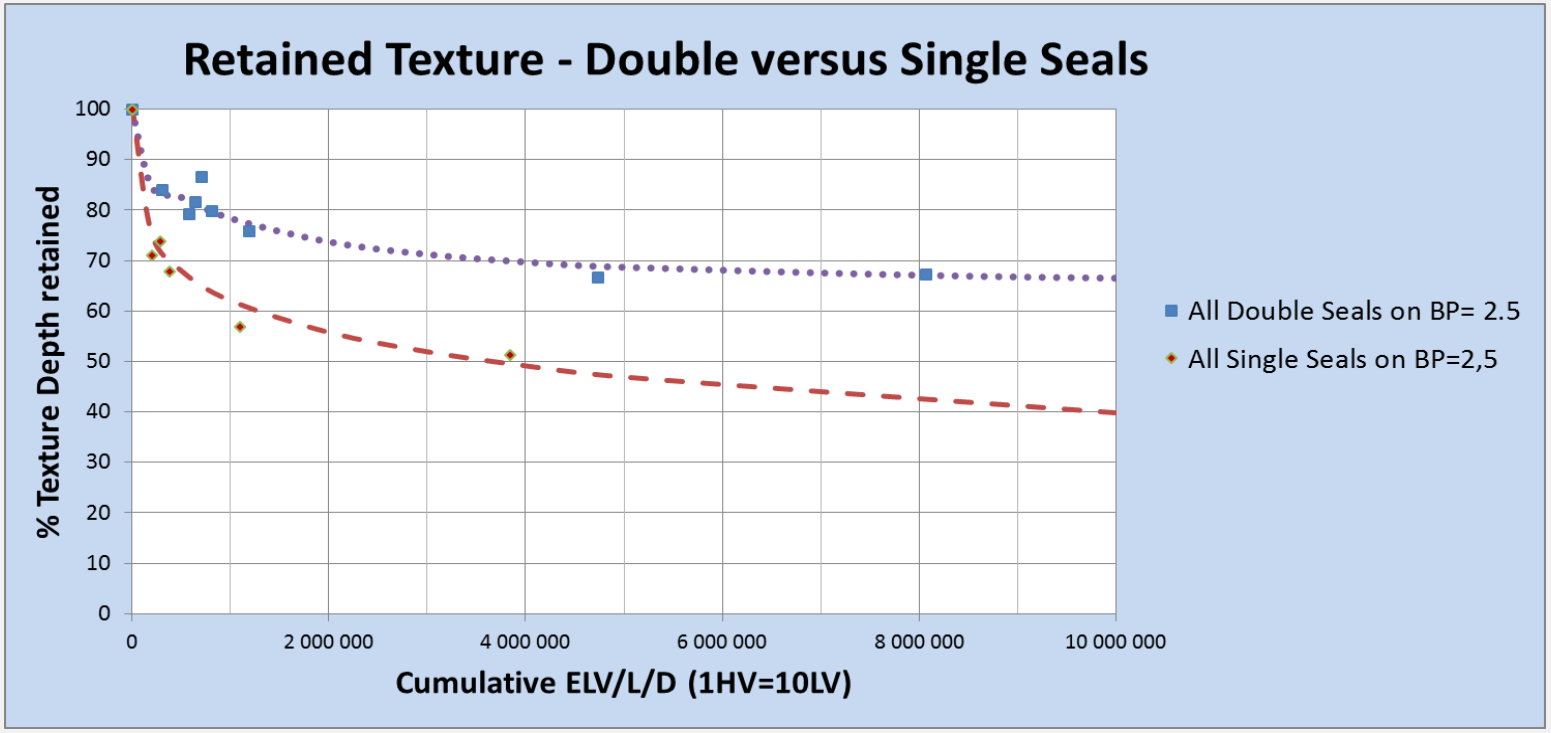
Loss of Macro Texture

- **Single Seals**



Loss of Macro texture

- **Double versus single seals**



FEM Texture loss

- **Effect of subgrade stiffness**

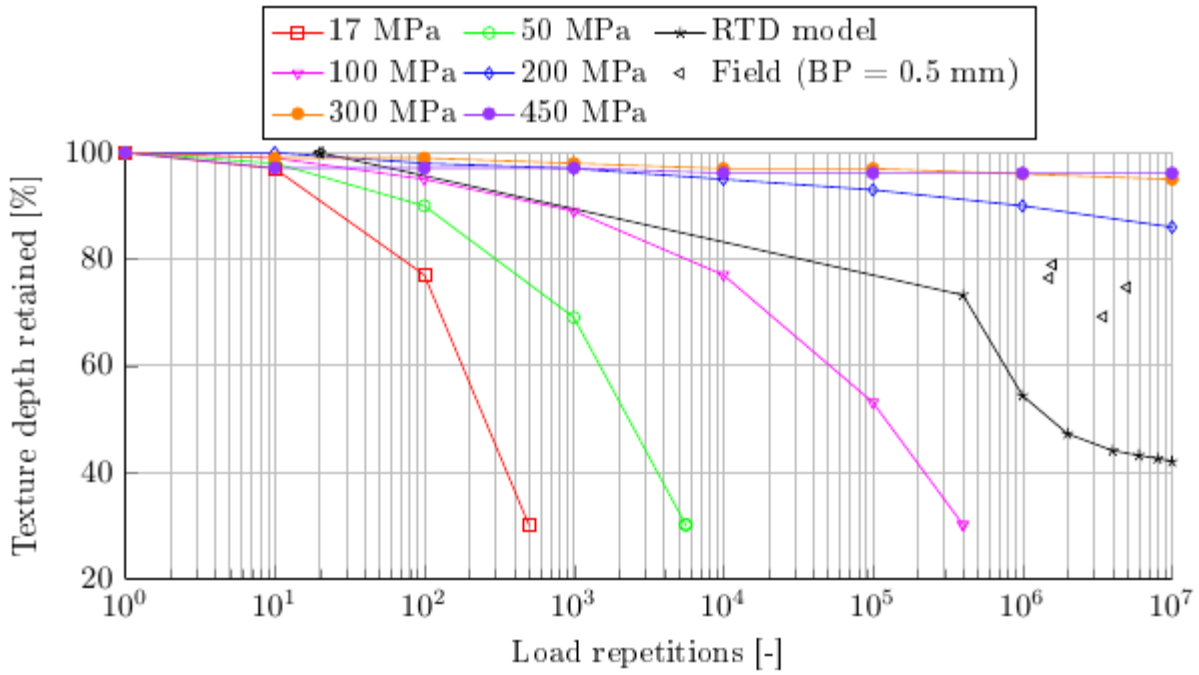
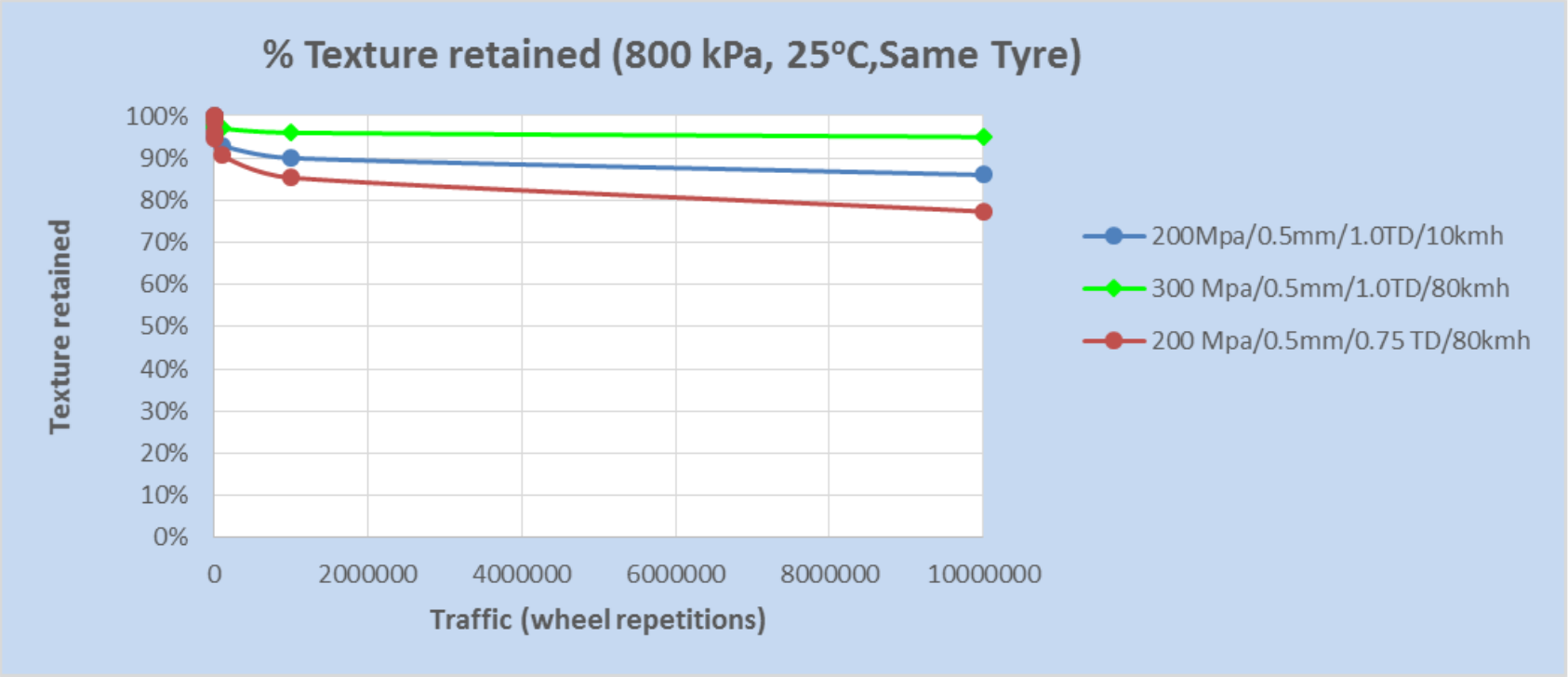


Figure 4.34: Validation of the FE seal model in terms of base stiffness with the RTD model and field data. Temperature: 25°C, traffic load: 20 kN-800 kPa at 80 km/h.

FEM Texture loss

- **Linear scale**
  - Similar trend as empirical model



Summary

- **Still some work to do**
  - Other binders and lower temperatures
  - FEM Double and Cape Seals
  - Empirical models
    - Multivariate analyses
    - Test on large data sets
- **Value of FEM**
  - Input into SAPDM
    - Recursive modelling using true traffic, climatic influences

End