TG2 Update
BSM technology
Foam and Emulsion

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RPF

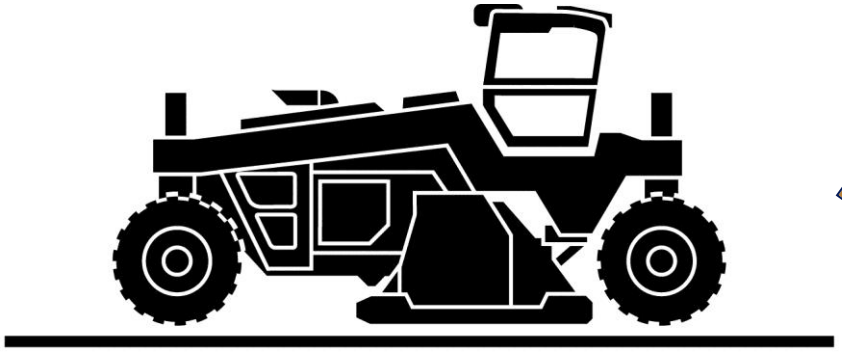
8 November 2016

Outline of TG2 update

1. Investigations
2. Mix Design
3. Structural Design
4. Application

2012

2002



2009

Investigations (New Chapter)

- Materials in distressed pavements
- Sampling
- RA Blends
- Uniform Sections
- DCP, FWD etc

Specifically for Recycling and Rehab

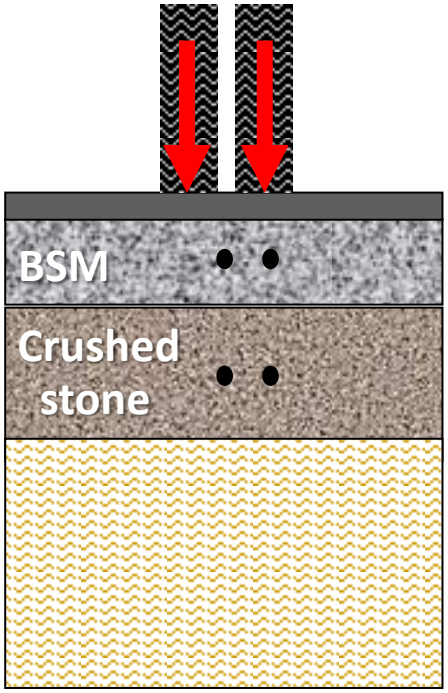
See the whole scene…..

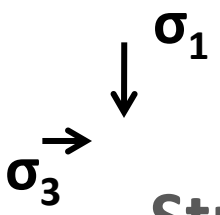
MIX DESIGN

Granular Layer Approach for BSM

Rutting = f (σ_d)

Shown by Maree & van Niekerk for granular materials





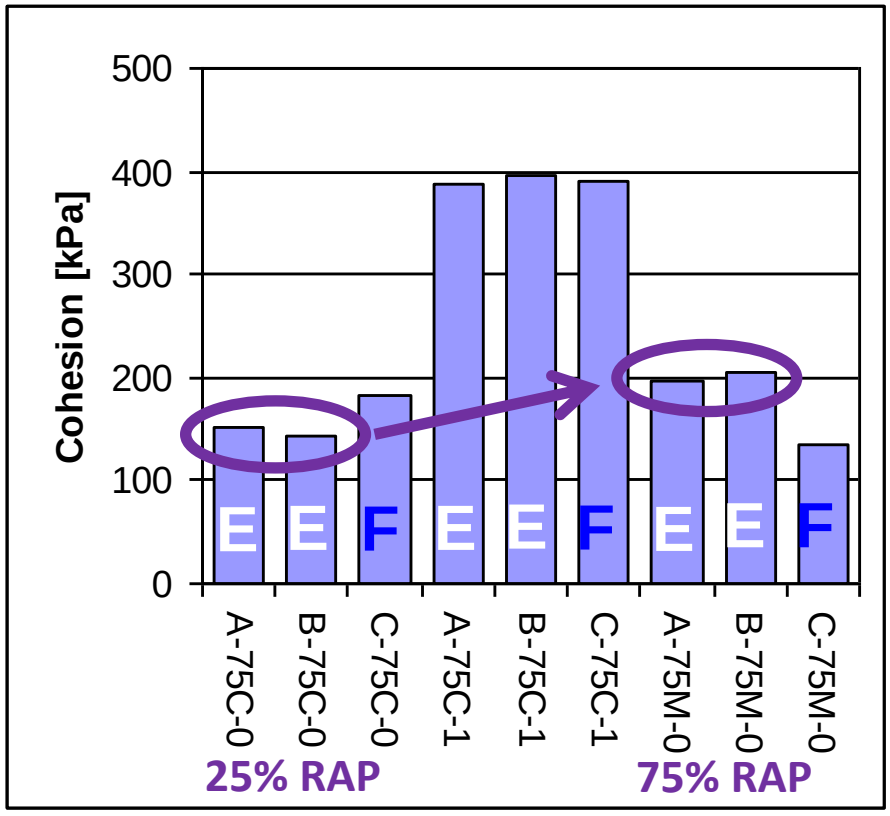
Stress state

Deviator stress (σ_d) = $\sigma_1 - \sigma_3$

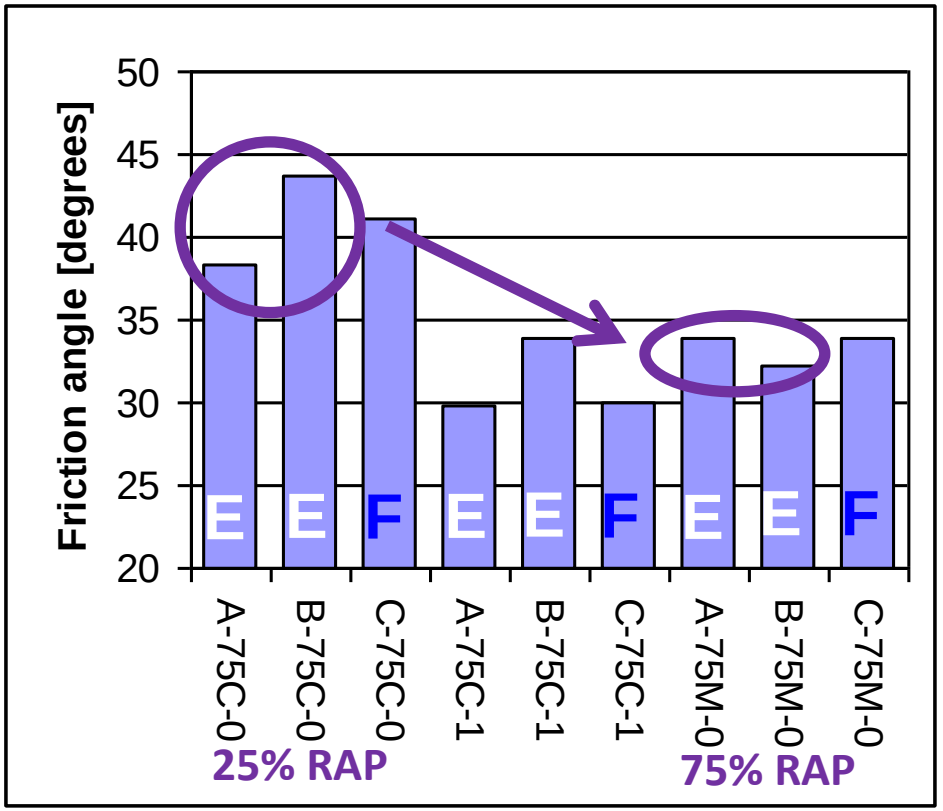
BSM Triaxial Tests Shear properties

(monotonic tests at 25°C)

Cohesion C

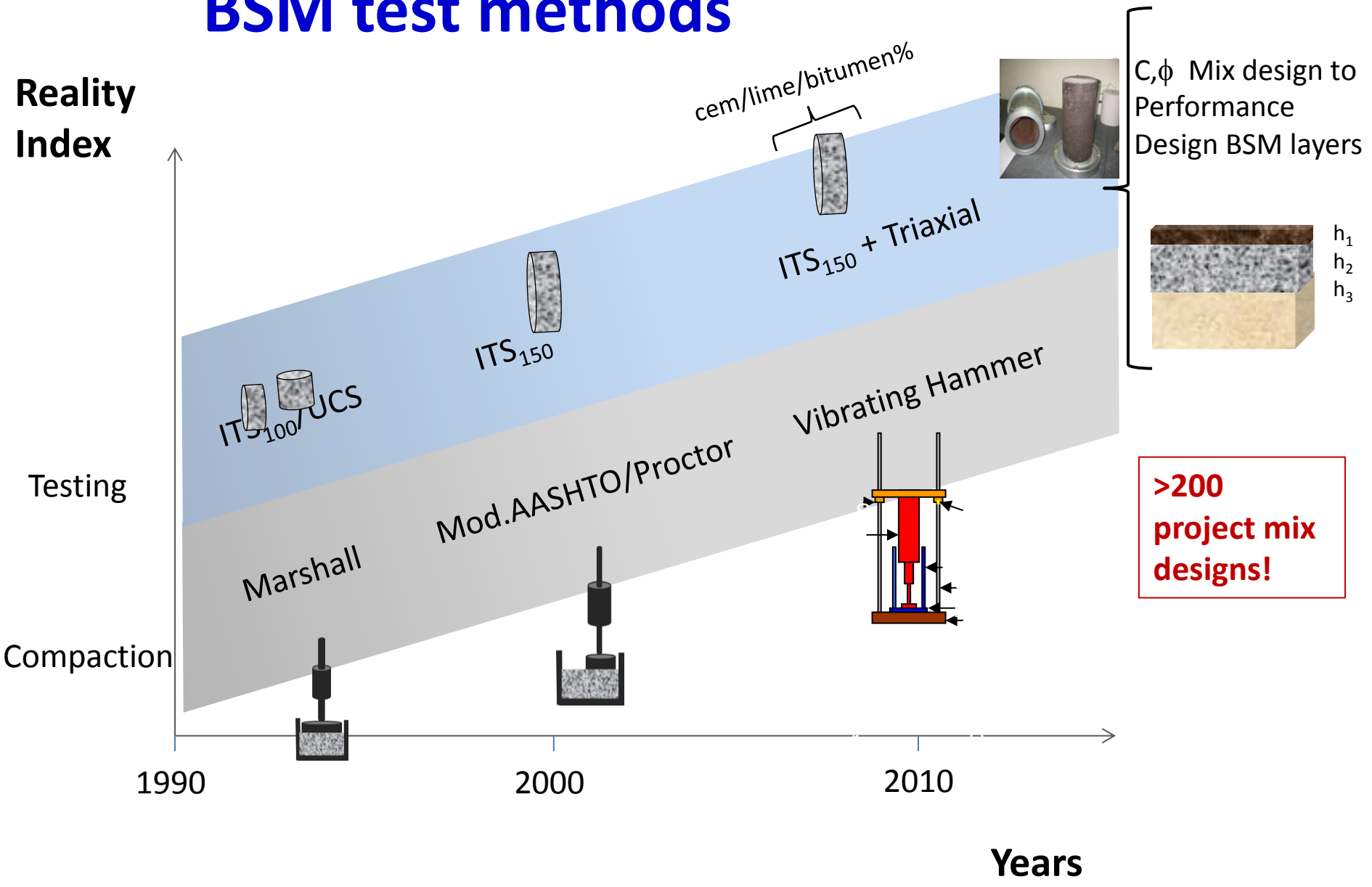


Friction Angle ϕ



Jenkins, 2000 & Ebels, 2006

BSM test methods



Why supplementary tests?

ITS 150ϕ tests

COV high

Triaxial 150ϕ tests

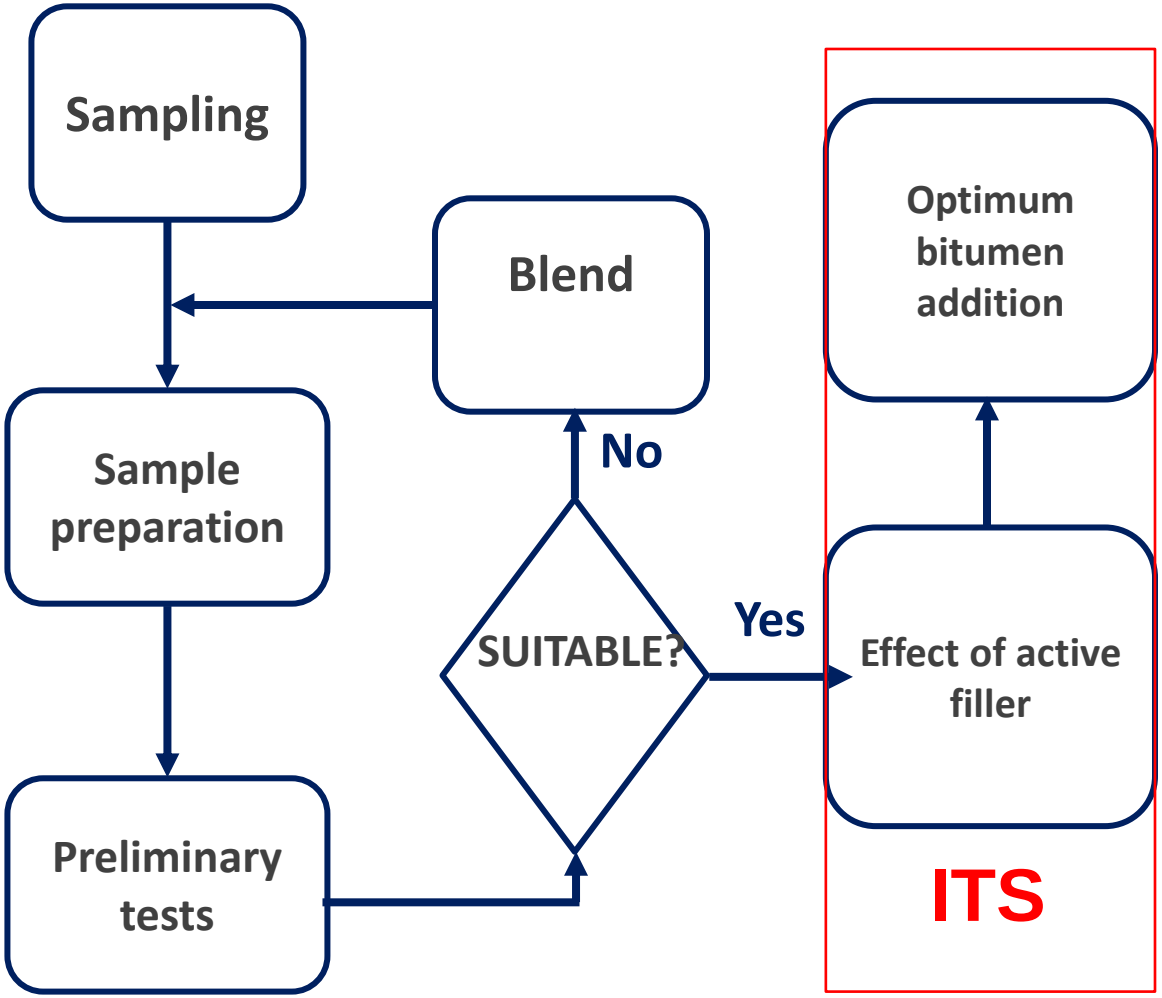
COV moderate

COV low

Controlled RAP

Direct link from Mix to Structural Design

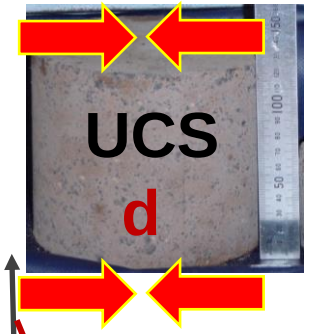
MIX DESIGN FLOWCHART



Specification	
ITS_{dry} (kPa)	ITS_{wet} (kPa)
>225	>100

Std Test Method

So where is UCS?



Erkens, 2000

Standardised Mixing Method

Lab Compaction: Vibratory Hammer

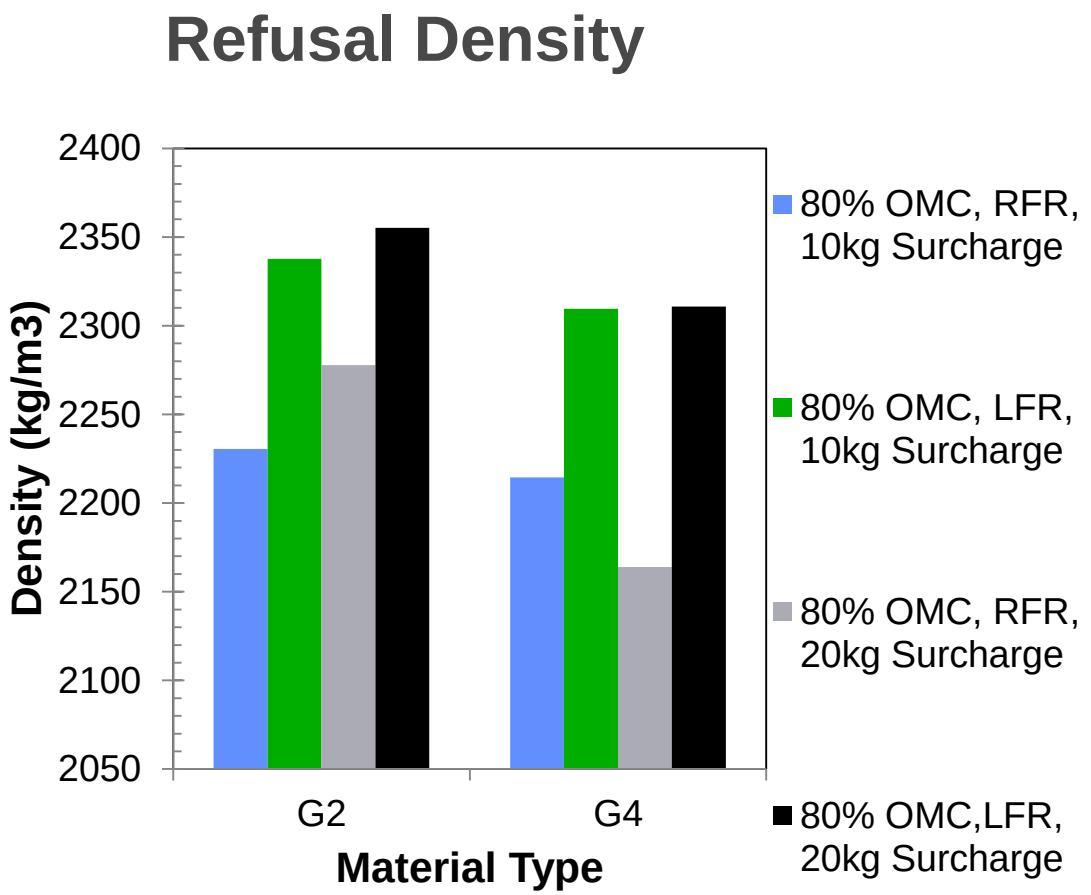
Vibratory hammer	Power rating (W)	Frequency (Hz)	Mass (Kg)	Point Energy (J)	
Kango 637®	750	45.83	7.5	27	★
Bosch GSH 11E®	1500	15 - 31.5	10.1	16.8	★
Bosch GSH 11VC®	1700	15 - 30	11.4	23	

★ For PI >8%, cannot achieve 100% Mod. AASHTO density

Influence of Frame


Rigid Frame


Loose Frame



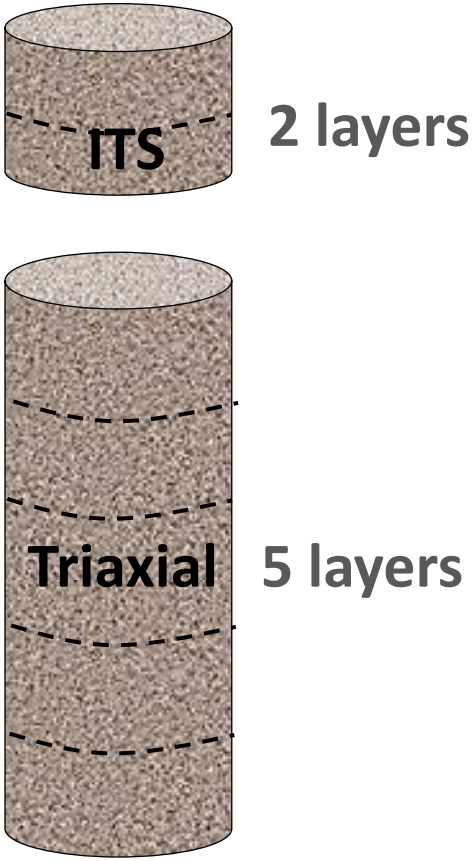
FRAME TYPE
Rigid
Loose
Rigid
Loose

Comparison of refusal density for G2 and G4 material

Std Test Method

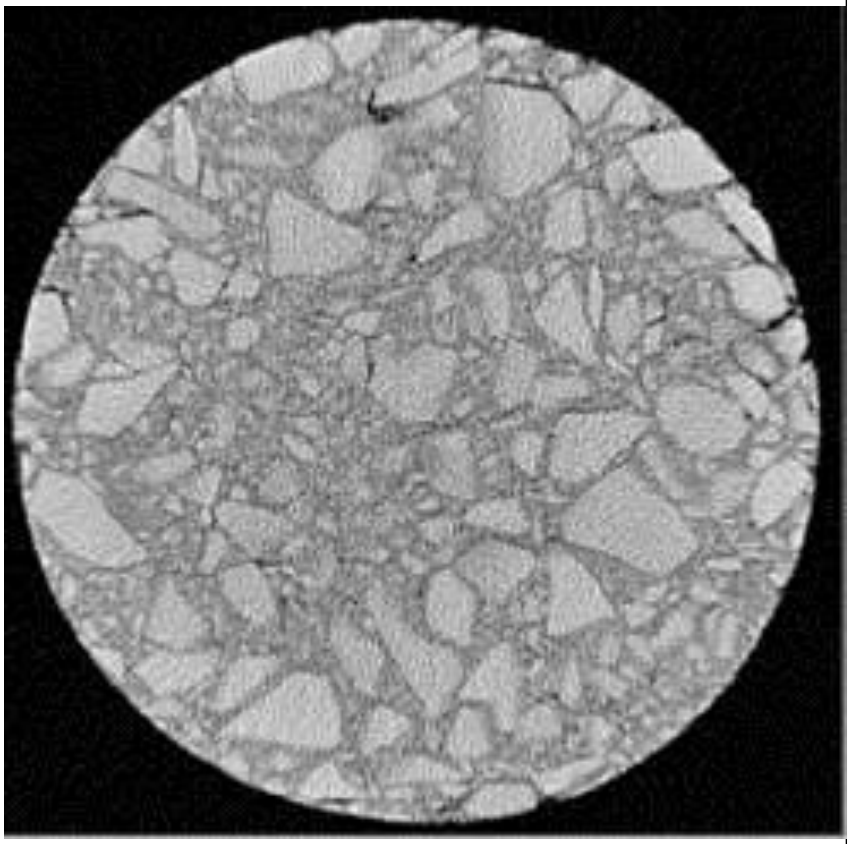
APPROVED

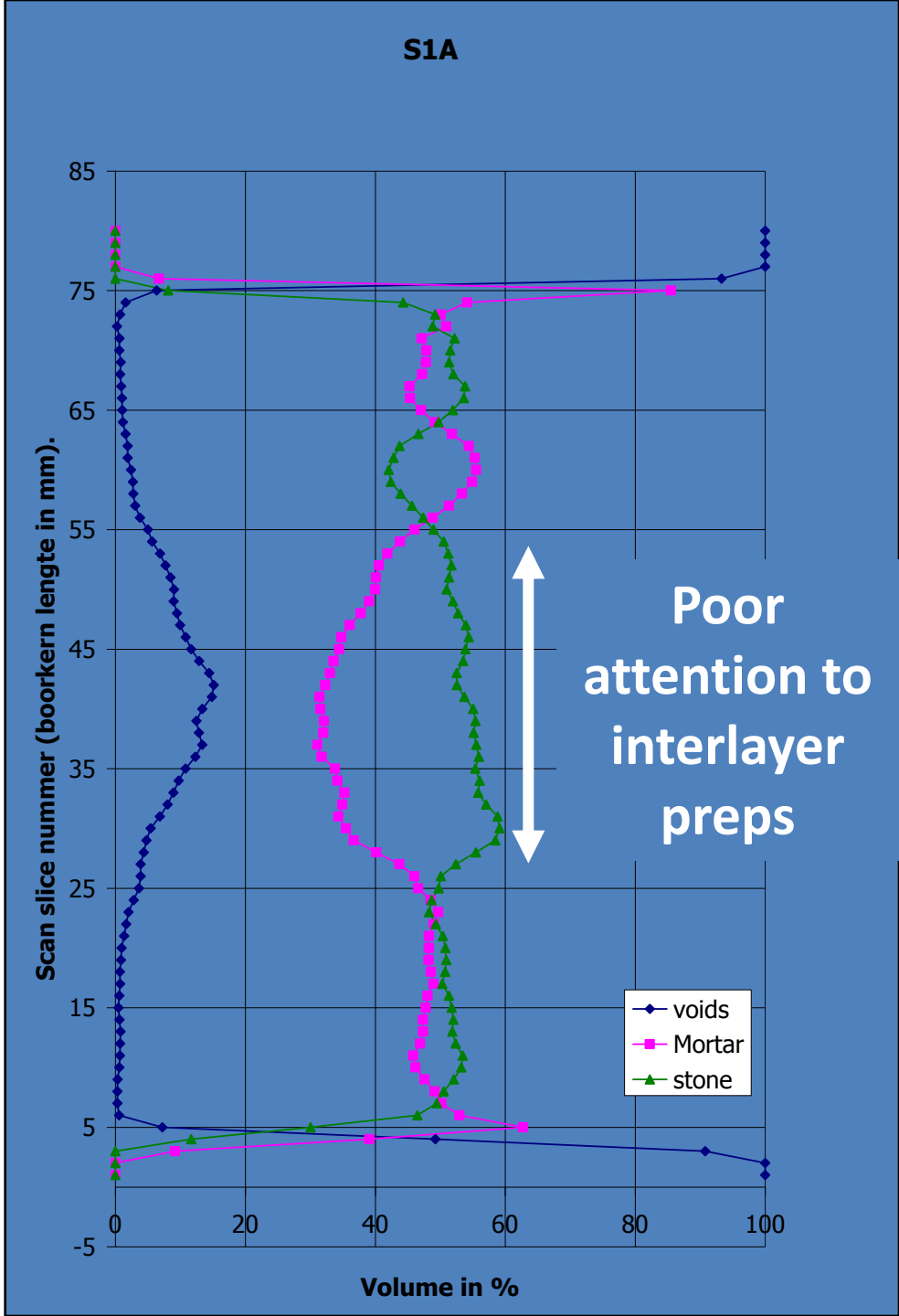
Inter-Layer Roughening (ILR) Device



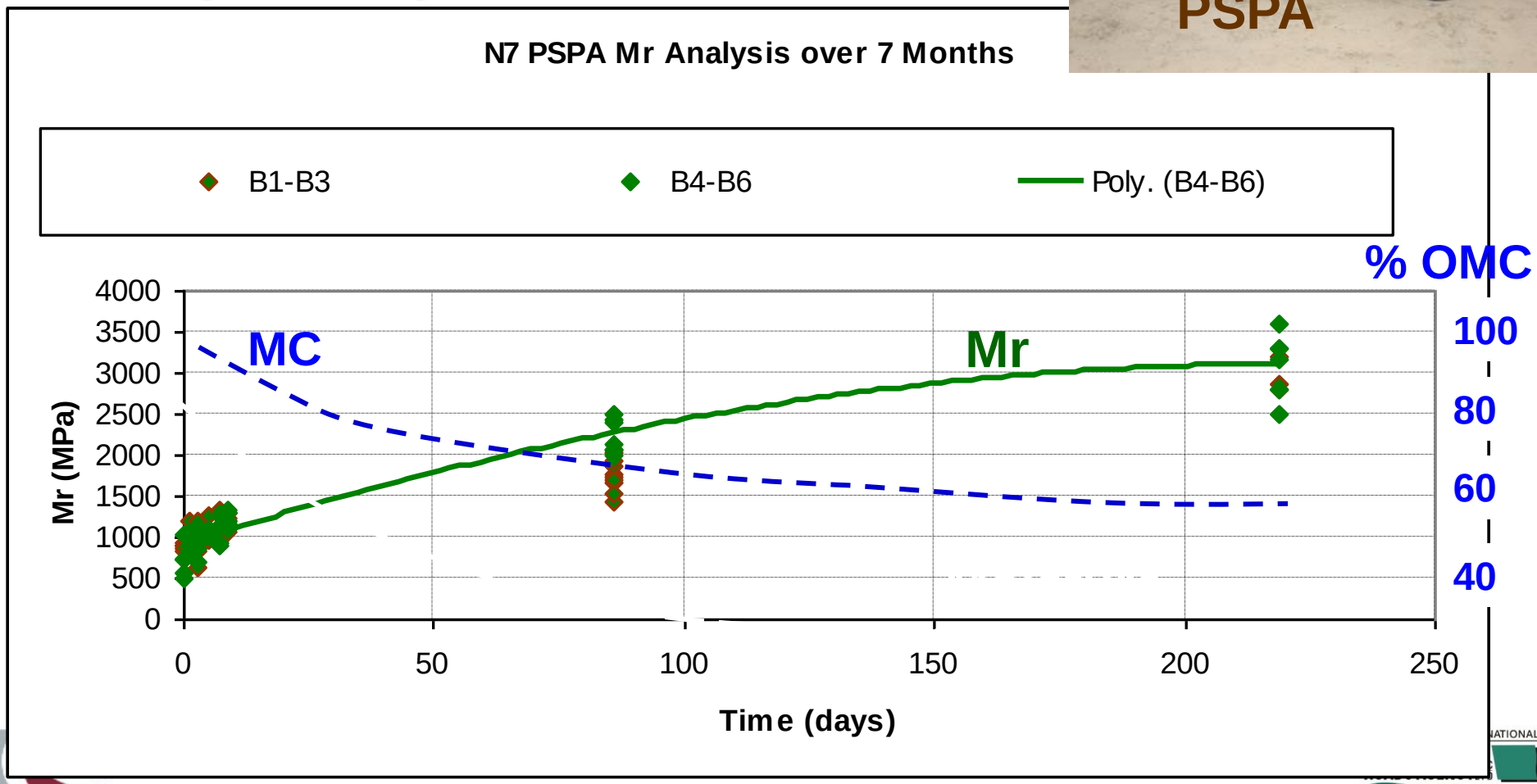
Inventor: Wynand van Niekerk

CT Scans
BSM-emulsion

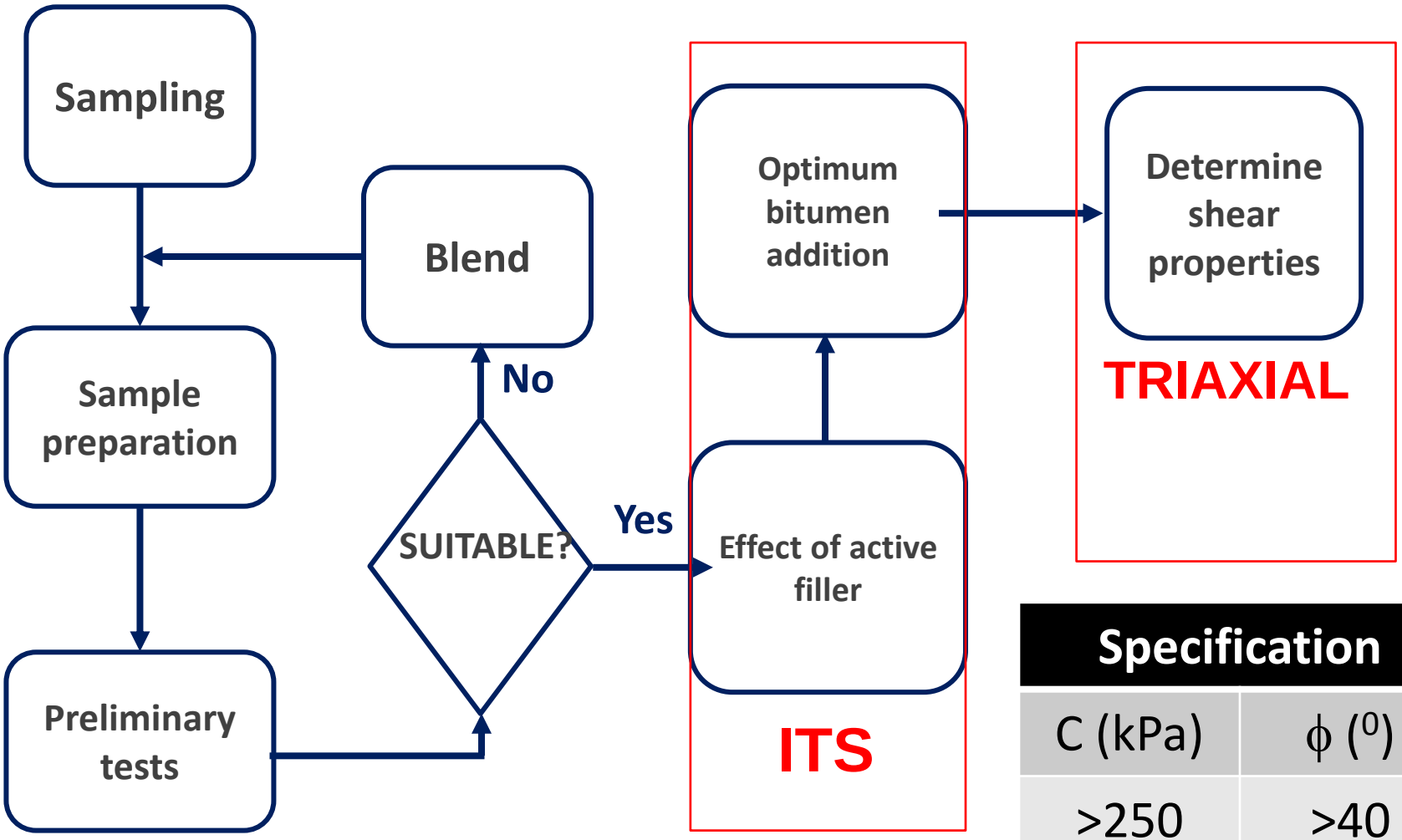




Why is curing important?
Mr (field) versus cure

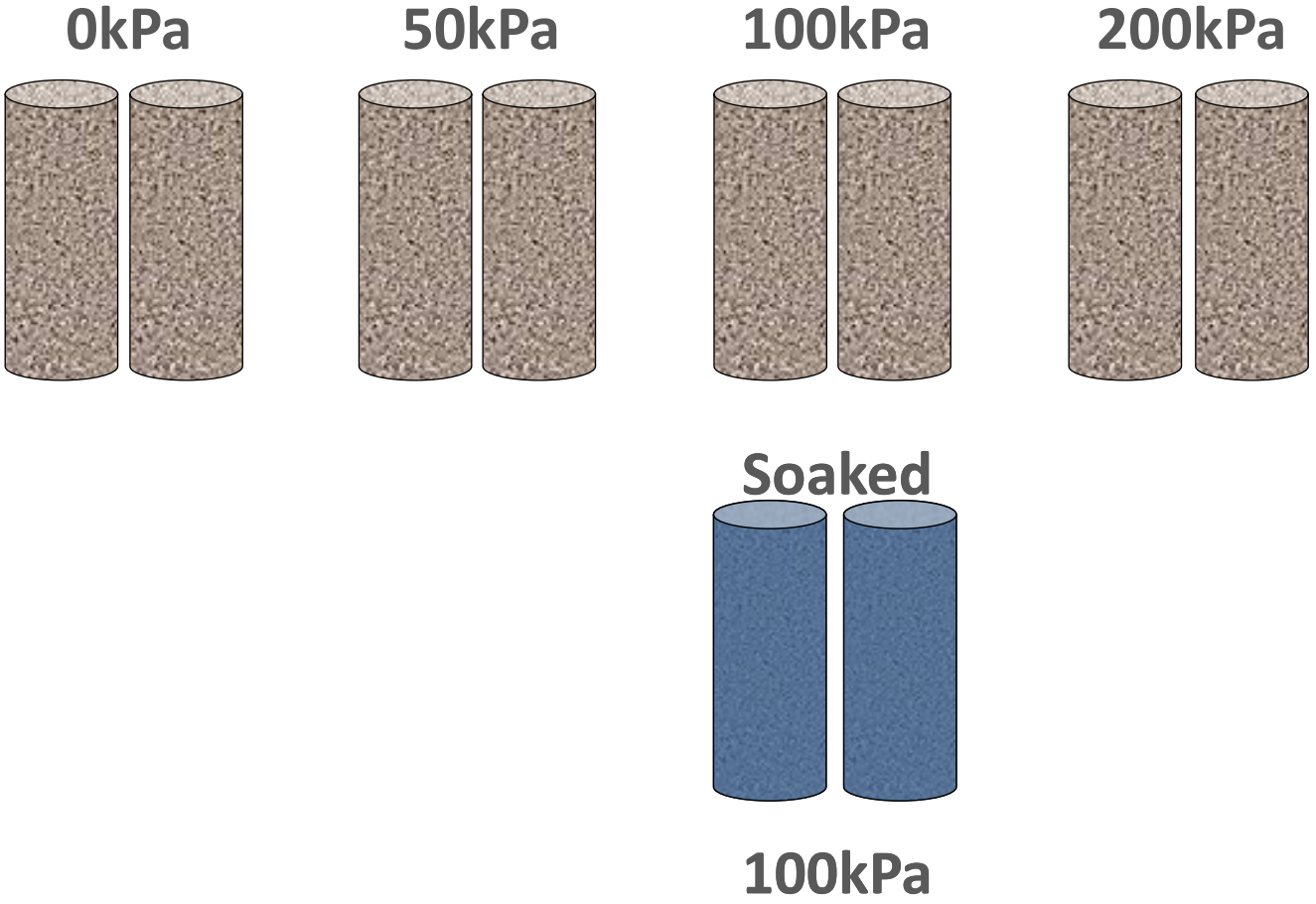


Mix Design Flowchart



Specification	
C (kPa)	ϕ (^{0})
>250	>40

Specimen Pairs
Tested at 4 different confining pressures



New Triaxial

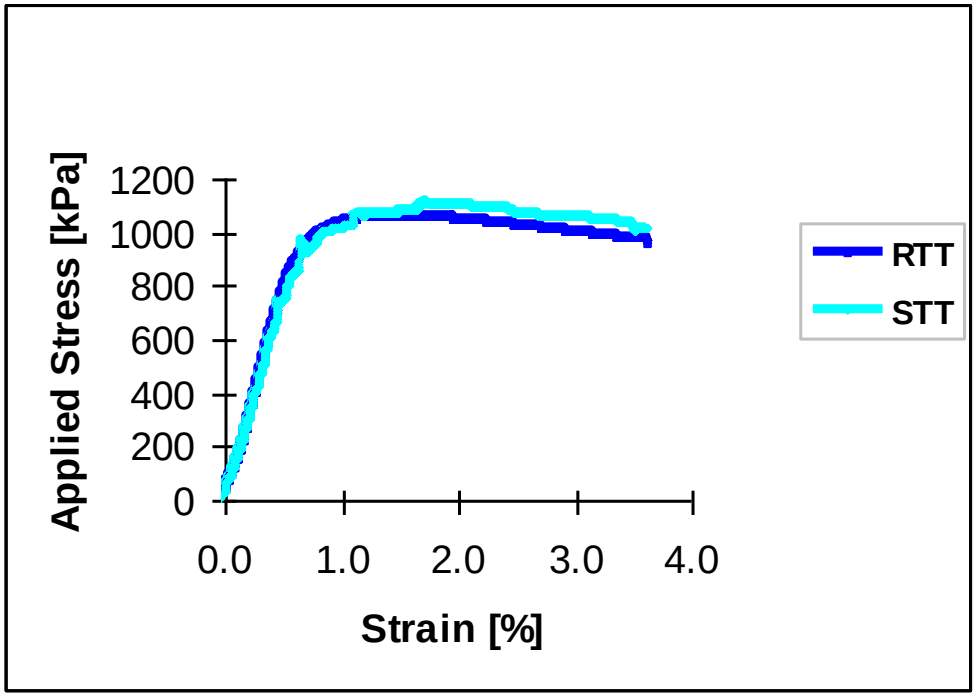
Apply Load (stress σ_1)

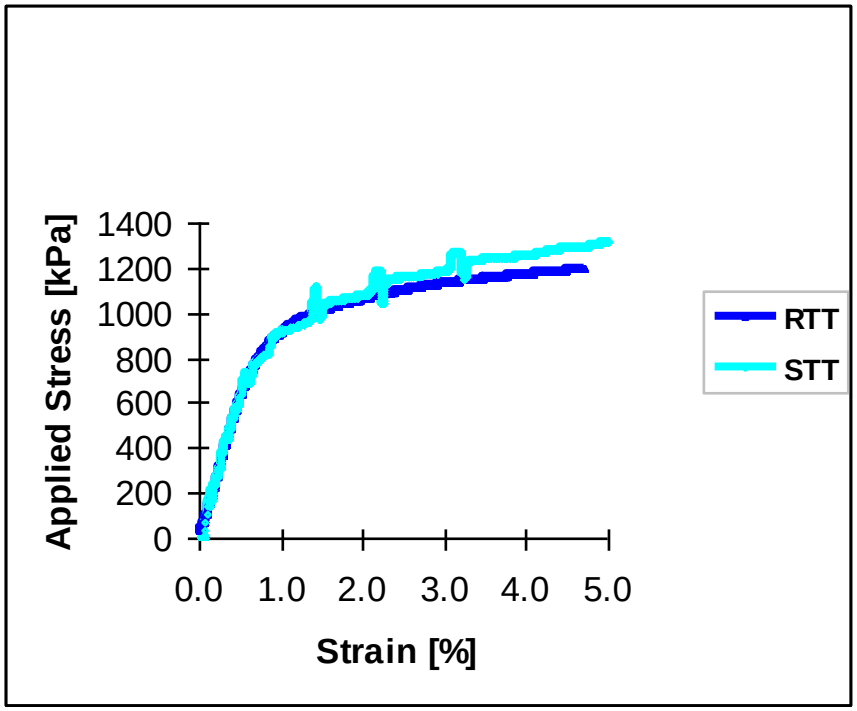
Test at 25°C

Confining Pressure σ_3 (inflate tube)

Validation

Research Triaxial Test RTT versus Simple Triaxial Test STT





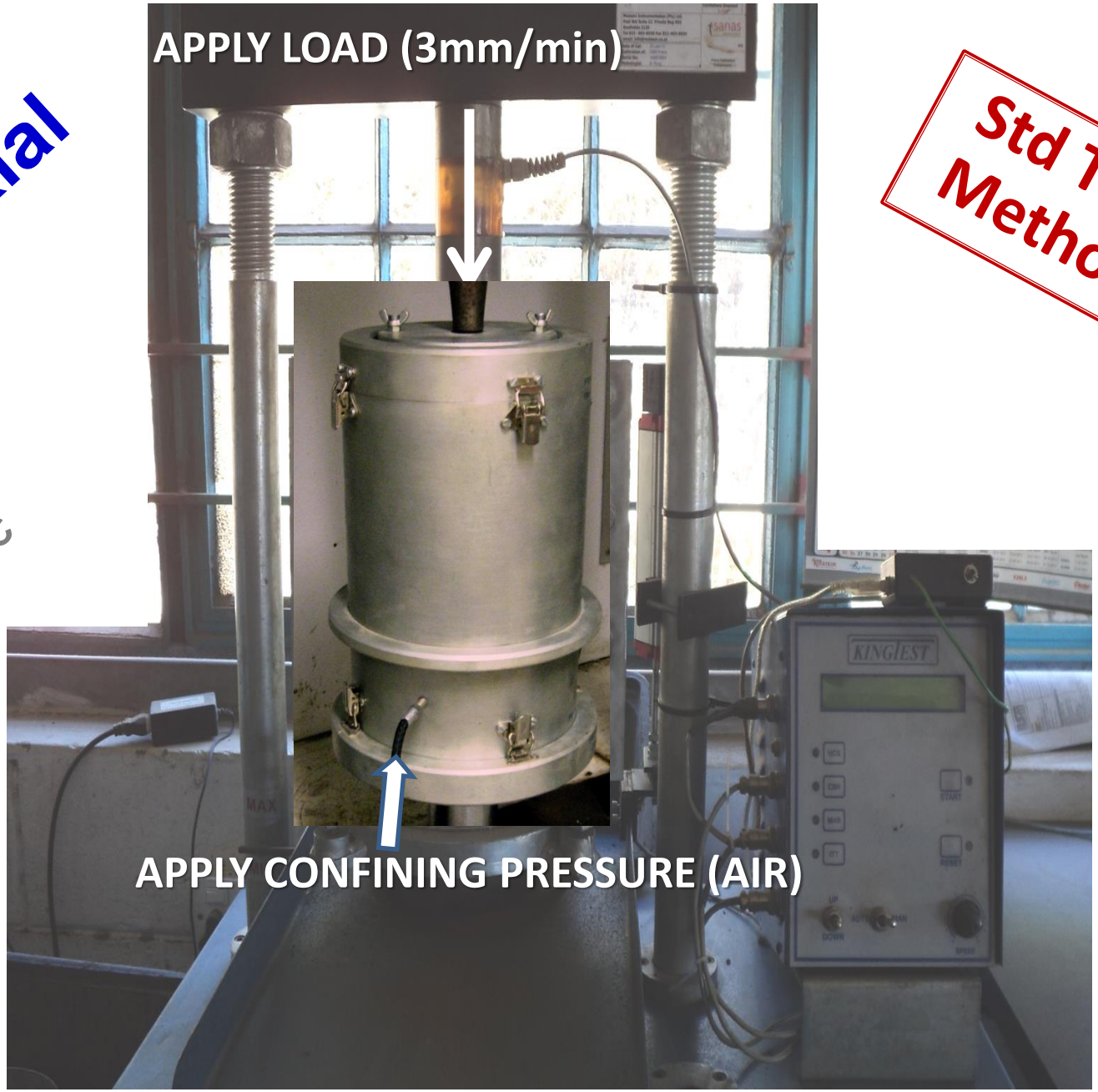
BSM Crushed Hornfels with 3.3% Emulsion

σ_3 =50 kPa and 1% Cement

σ_3 = 200 kPa and 0% Cem

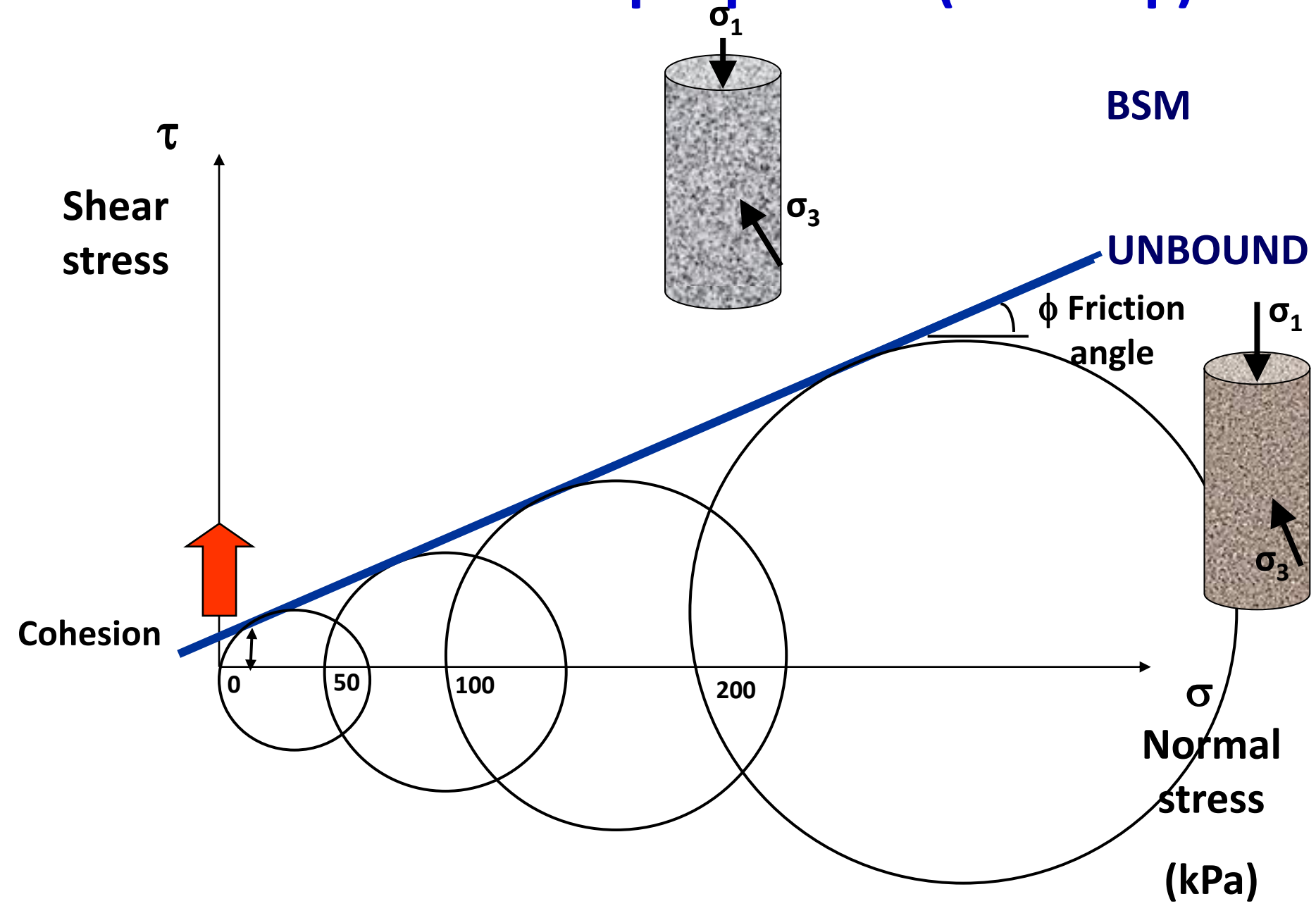
Triaxial

Tests @ 25°C

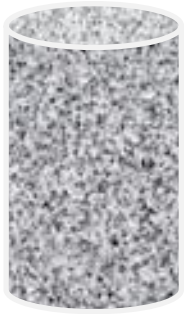


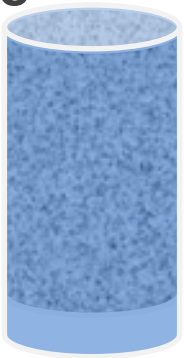
Std Test Method

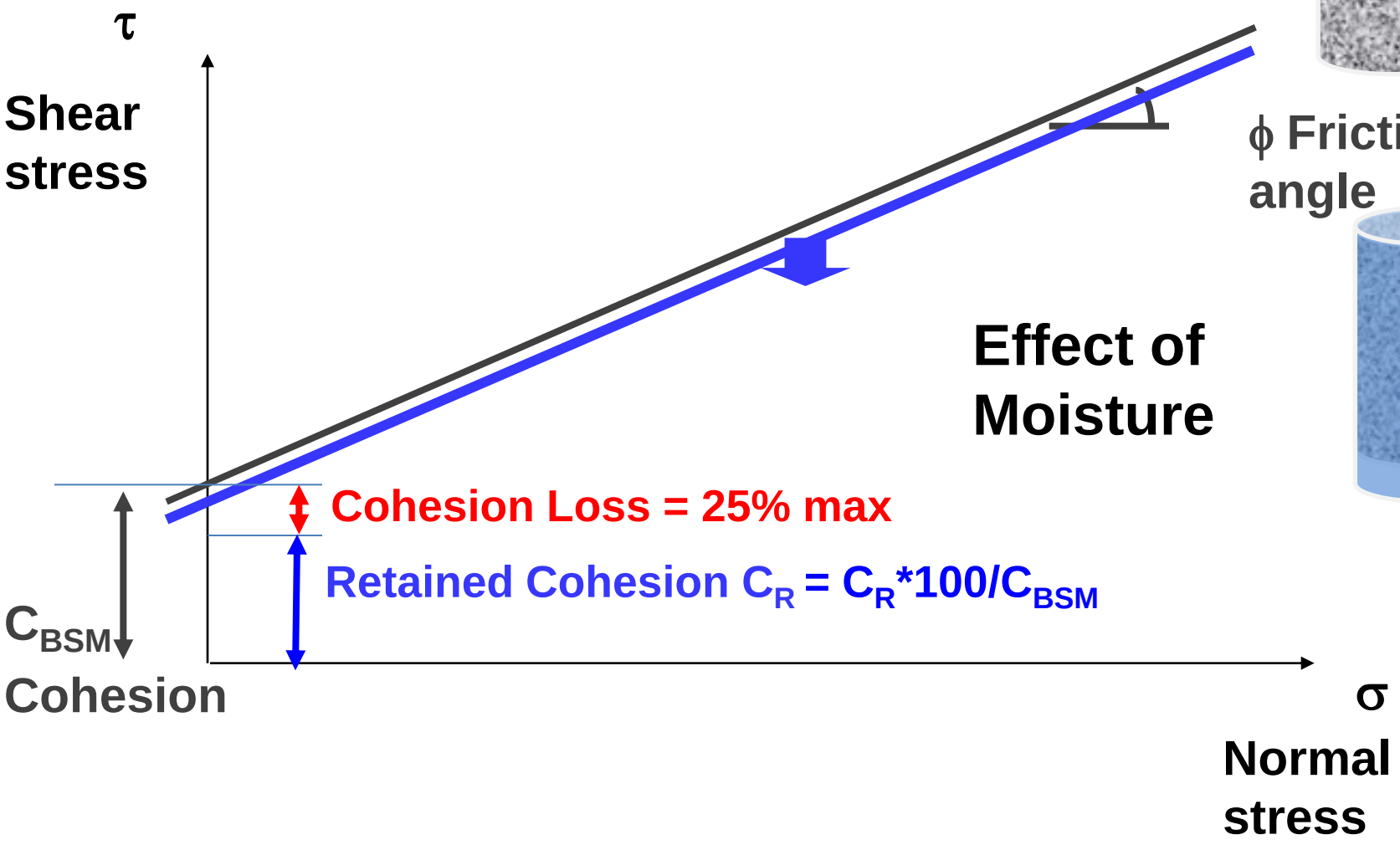
Determine shear properties (C and ϕ)



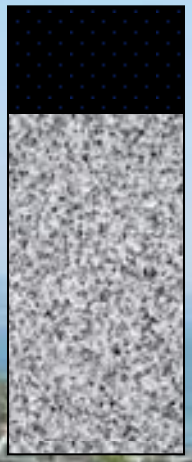
Effect of moisture on BSM







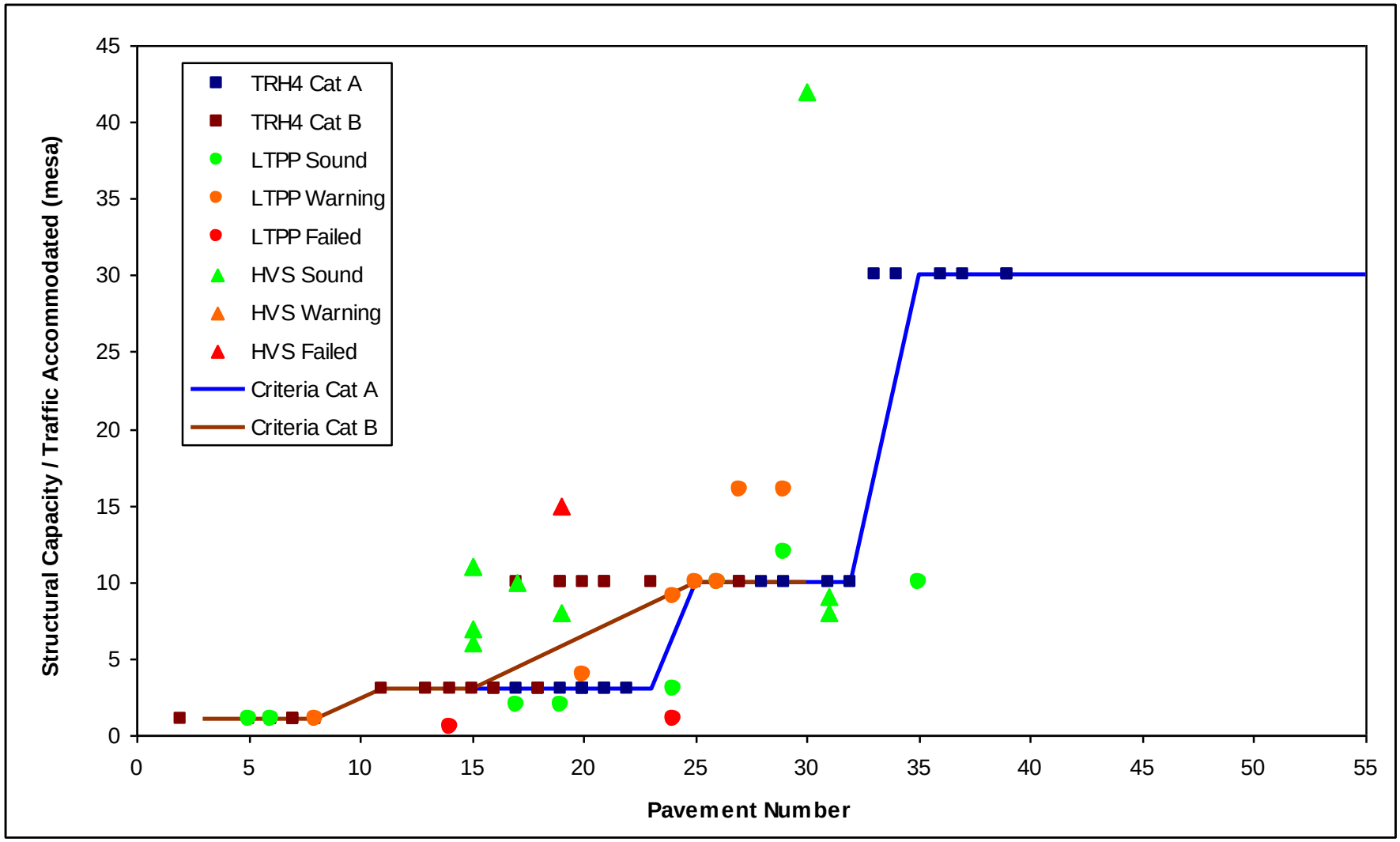
Structural Design Considerations



90mm Asphalt

250mm CIPR:
2.5% Foam 1% Cem

Materials Classification and Pavement Number

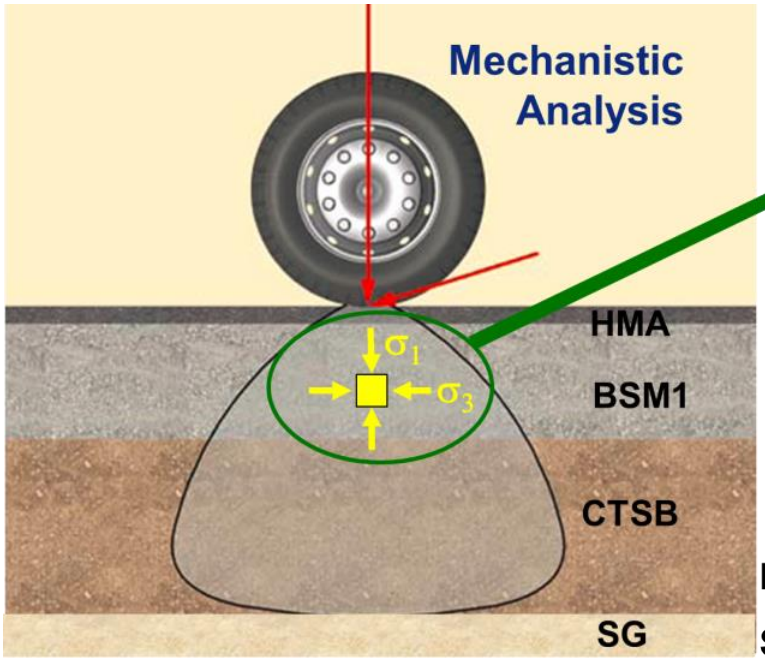


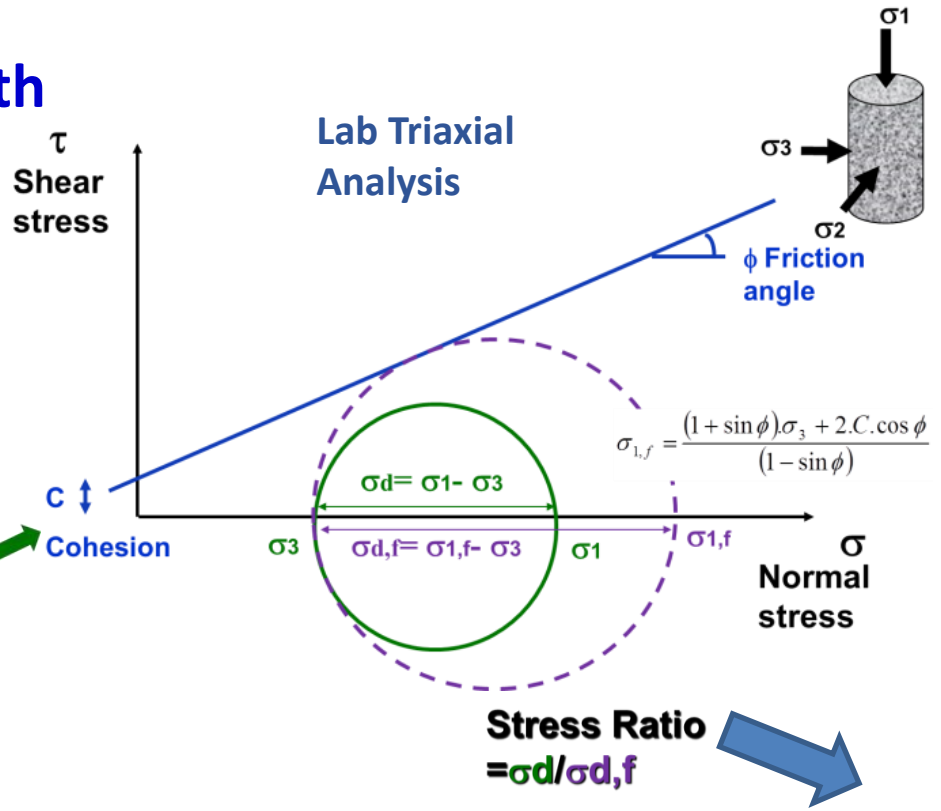
Updates to DEMAC & PN

- **DEMAC (Materials Classification)**
  - Improve system for cemented materials
- **Pavement Number**
  - Adjust Asphalt and CTB contributions
  - "Smoothed" frontier curve
  - No budget for updated in-service data
- **Update (2016)**
  - Currently available in Rubicon Toolbox Online Tools (www.rubicontoolbox.com)
  - BitMat 25 Oct: Materials Classif & PN belong in SARDS not TG2. First update in SAPEM

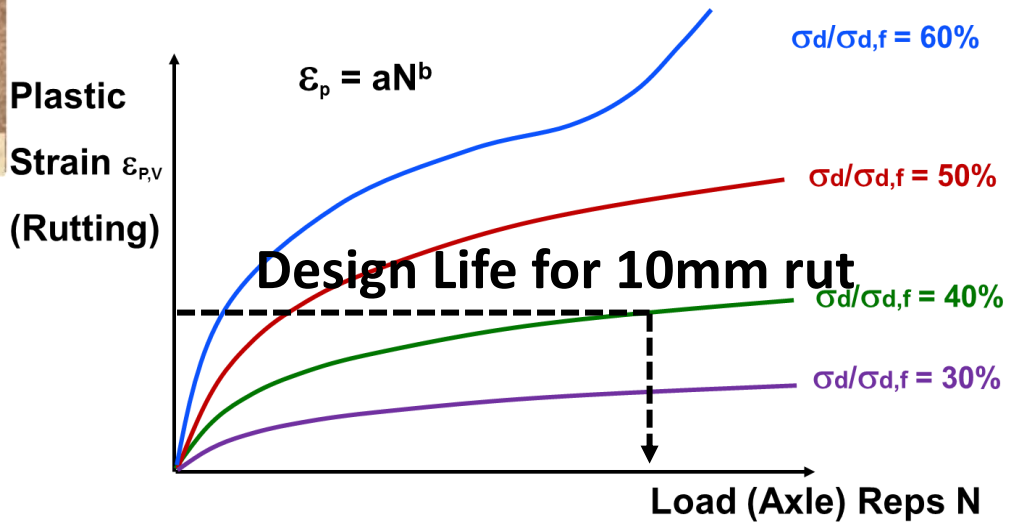
BSM Design for Max Rut Depth

(same principle as Granular Design)





Stress Ratio =σd/σd,f

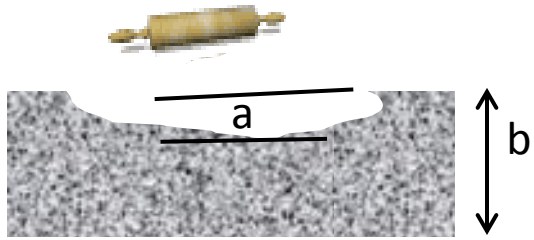


Permanent deformation (rutting) design for granular material

Design Function for BSM

Relative Density

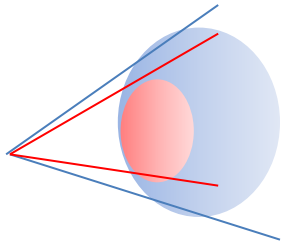
Plastic Strain (a/b)



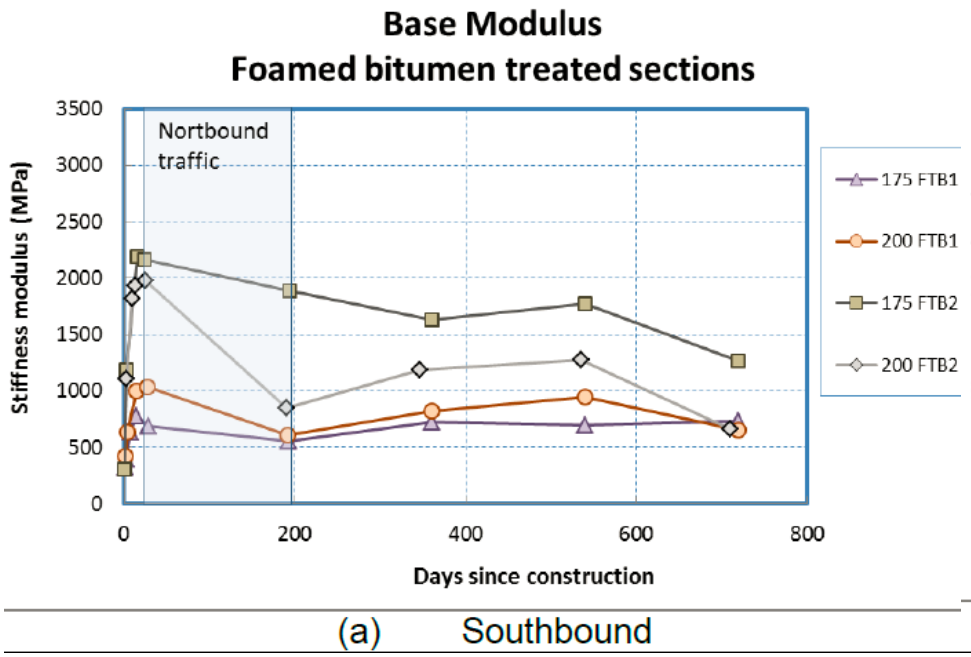
$$N = f\,(RD, RetC, PS, SR)$$

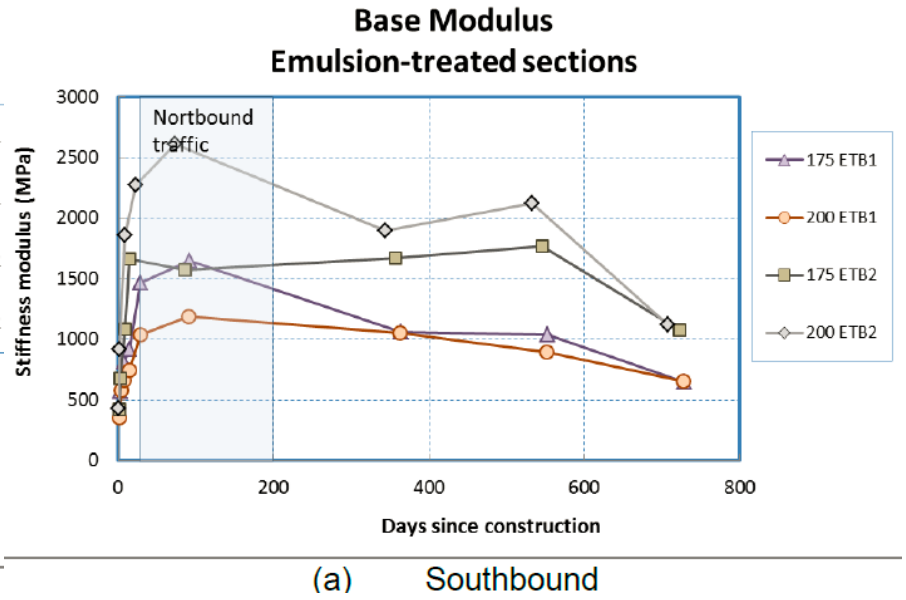
Retained Cohesion

Stress Ratio



Effective Long Term Mr for BSM base





SAPDM - R35 : Theyse, 2015 & Lynch, 2014

Effective Long Term Mr Stiffness (MPa) for BSM base

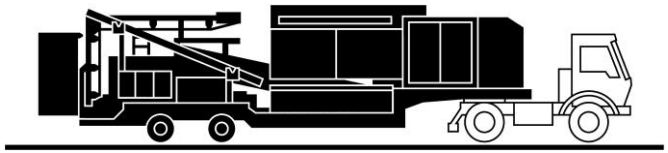
Supporting Layer

BSM Class	Cemented Subbase	Granular Subbase
BSM (RAP + GCS)	**900 – 1750**	**700 – 1200**
BSM (GCS Grade Crushed Stone)	**800 – 1200**	**600 – 900**

ELT Mr = f (aggregate type and quality, RAP %, bitumen %, support, traffic, climate)

Conclusions

- **Investigation for rehab (new)**
- **Mix design system in place**
  - Testing protocols
  - Equipment available (vib hammer & triax)
- **Pavement design**
  - Classification and PN to SAPEM first
  - New ME design function
- **Application (in plant and in place)**



The sky's the limit!

Thank you!

Stellenbosch

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