TG2 Update
BSM technology
Foam and Emulsion

## Kim Jenkins

RPF

15 November 2017

Stellenbosch

Cricket – a strange game

Cricket: Fielding positions for a right-handed batsman
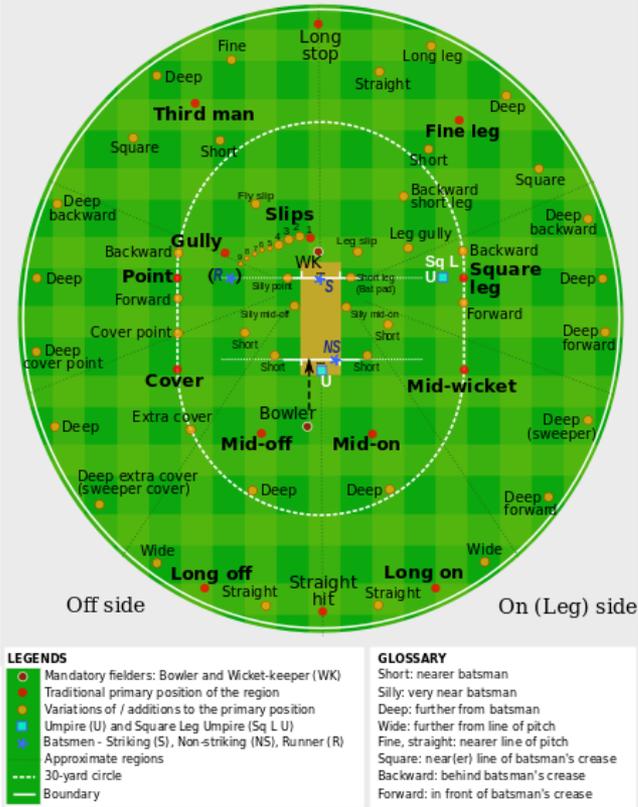
1974

1874

Chapters of updated TG2

1. **Introduction**
2. **BSM Usage & Design**
3. **Investigations & Classifictn.**
4. **Mix Design**
5. **Structural Design**
6. **Application**

2012
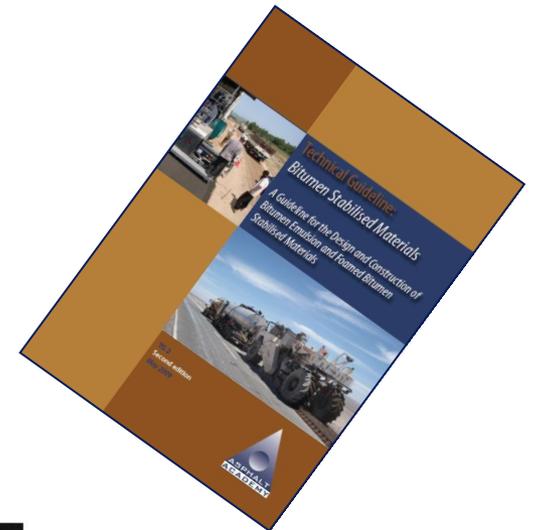
2002

2009

Investigation (new) & Classification
Focus on Rehabilitation

- **Materials in distressed pavements**
- **Sampling**
- **RA Blends**
- **Uniform Sections**
- **DCP, FWD etc**
- **Strip Maps**
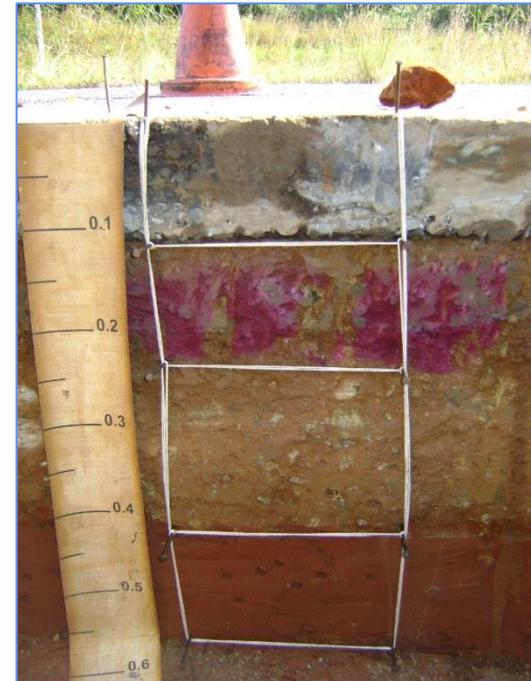
Specifically for Recycling and Rehab

BSM test methods

Reality Index

cem/lime/bitumen%

C,ϕ Mix design to Performance Design BSM layers

h_1
h_2
h_3

ITS$_{150}$ + Triaxial

ITS$_{150}$

ITS$_{100}$/UCS

Vibrating Hammer

Testing

Mod.AASHTO/Proctor

Marshall

>200 project mix designs!

Compaction

1990   2000   2010

Years

Mix Design Flowchart

Sampling

Blend

Sample preparation

No

Preliminary tests

SUITABLE?

Yes

Optimum bitumen addition

Effect of active filler

ITS

Determine shear properties
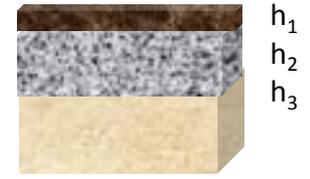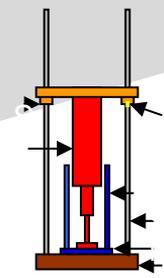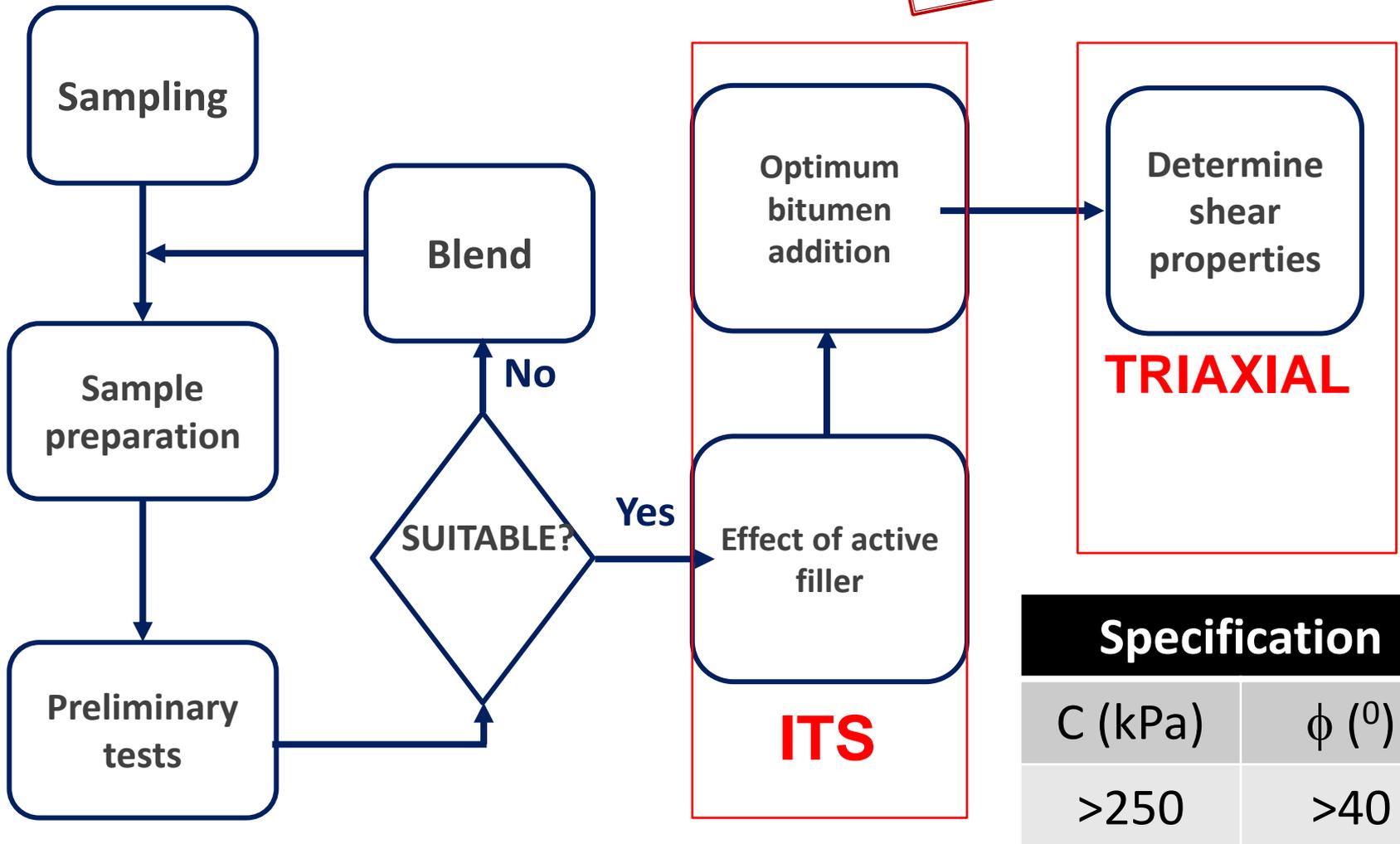
TRIAXIAL

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

Standardised Mixing Method

FOAMED BITUMEN UNIT

PUGMILL
MIXER
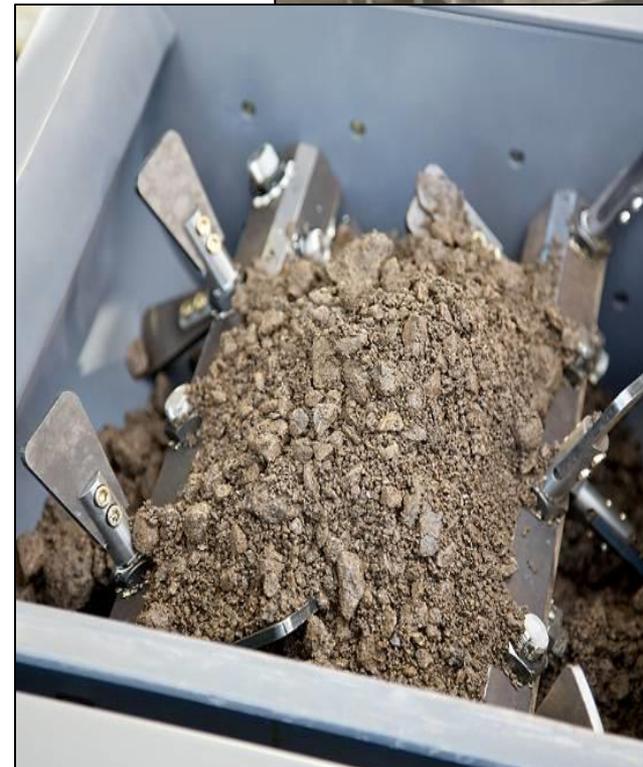
(Stell Univ)

Std Test Method

APPROVED

Triaxial Test Method

Test Temperature =   25⁰C
Displacement rate = 3mm/min

Determine shear properties (C and φ)

Effect of moisture on BSM

τ

Shear stress

φ **Friction angle**

Effect of Moisture

Cohesion Loss = 25% max

Retained Cohesion $C_R = C_R*100/C_{BSM}$

C_{BSM}
Cohesion

σ

Normal stress
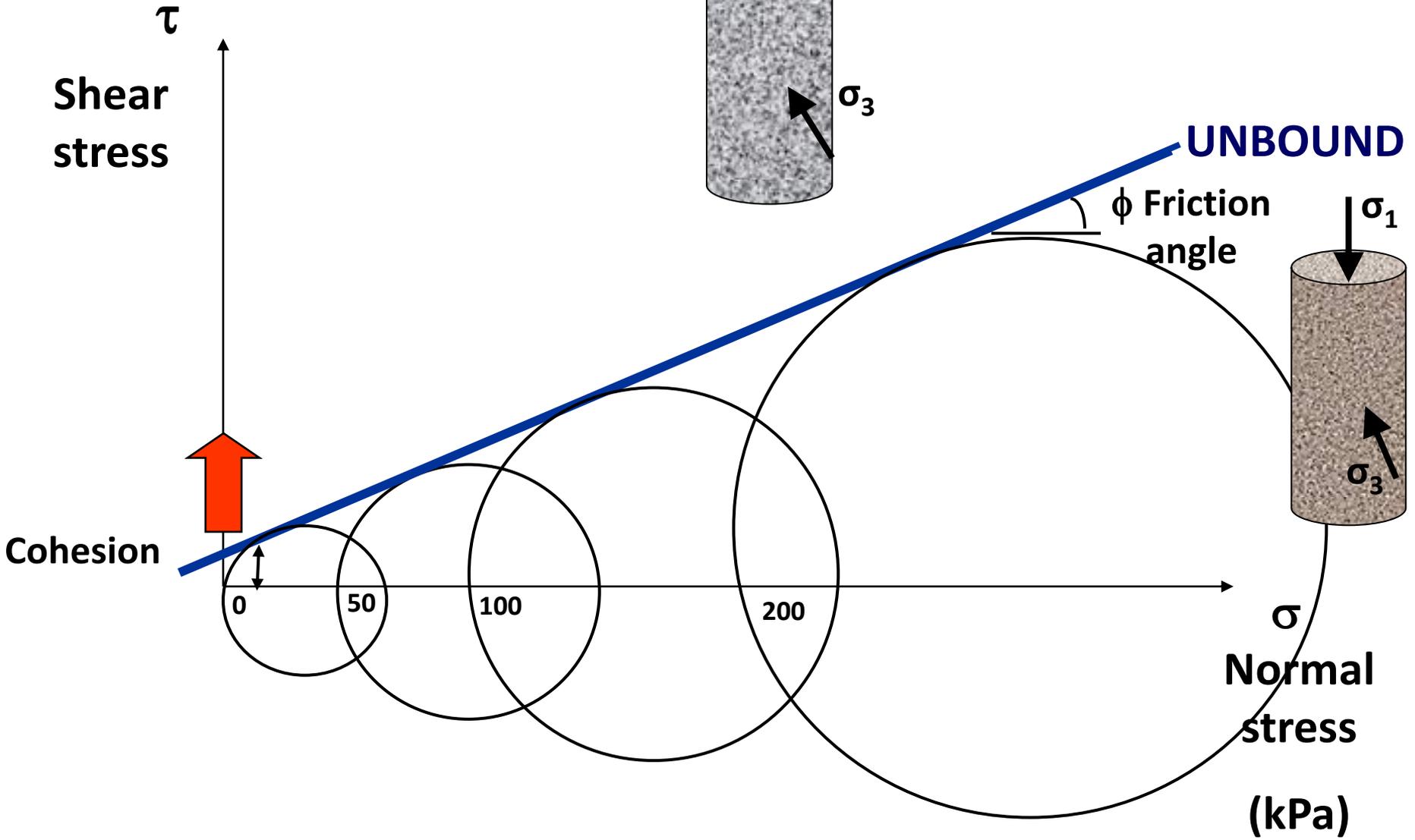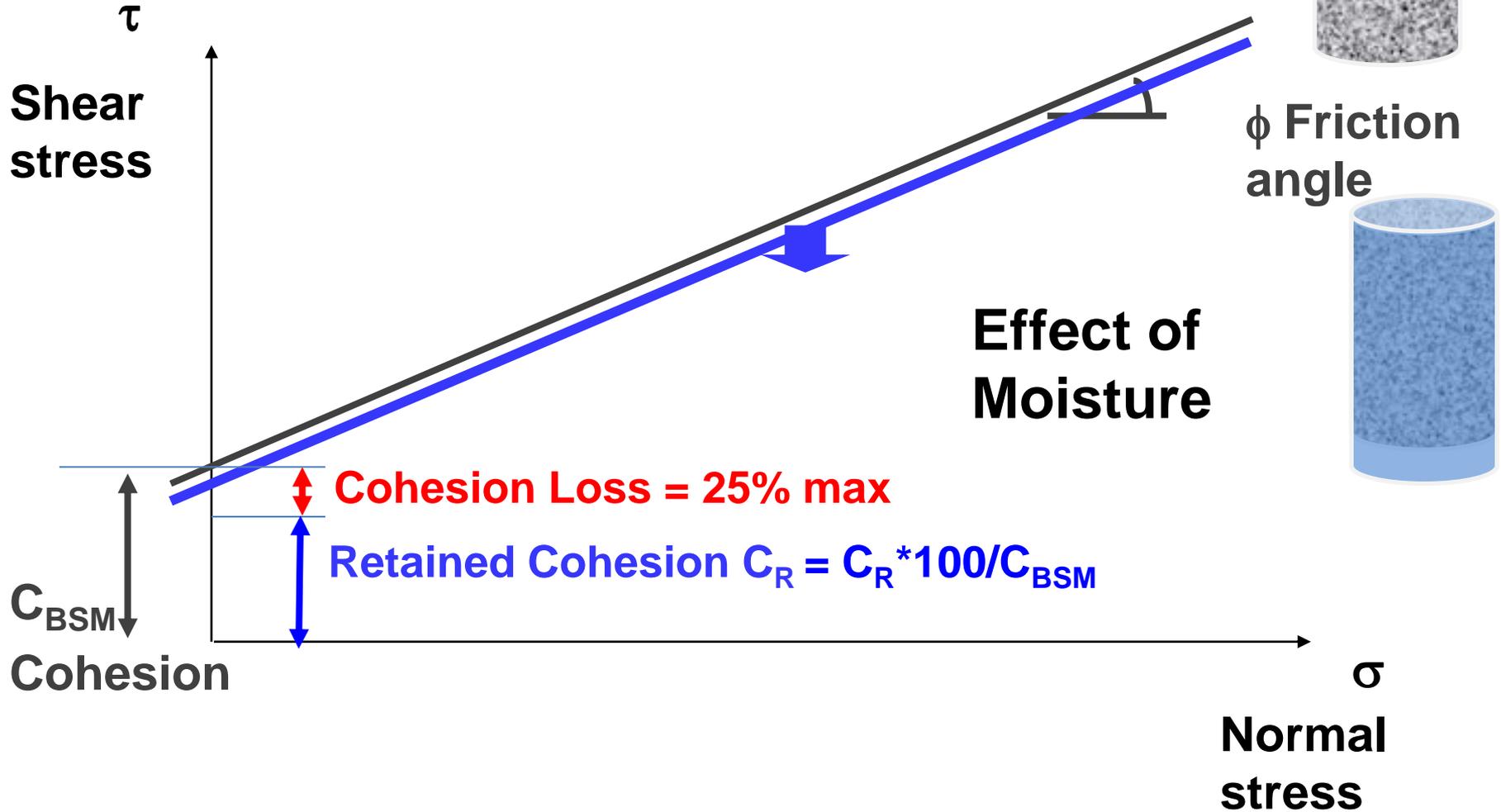
Structural Design Considerations

90mm Asphalt

250mm CIPR: 2.5% Foam 1% Cem
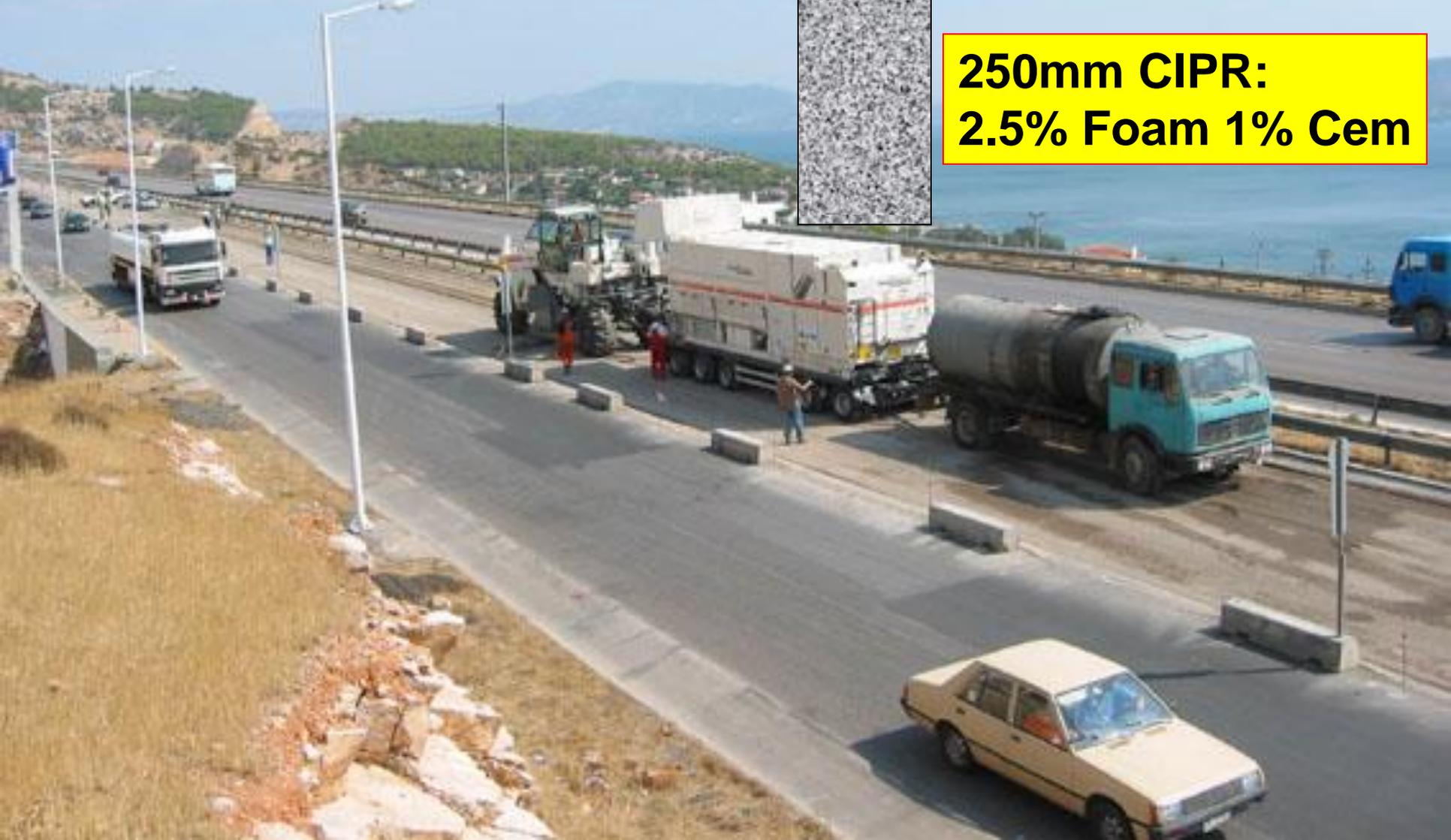
Updates to PN$_1$

- **Asphalt layers**
  - Surfacing currently *unconservative*
  - Base not accounted for

- **Cemented layers**
  - CTB currently conservative (similar to gran)
  - Unholy alliance between asphalt and cemented
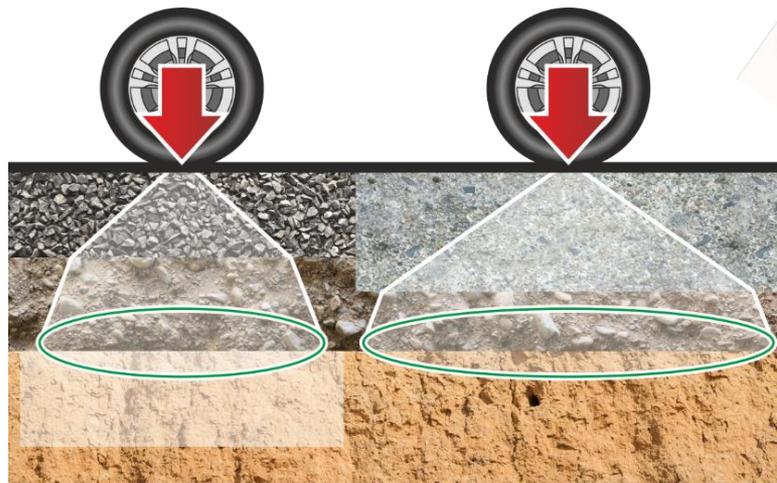
# Updates to PN$_2$
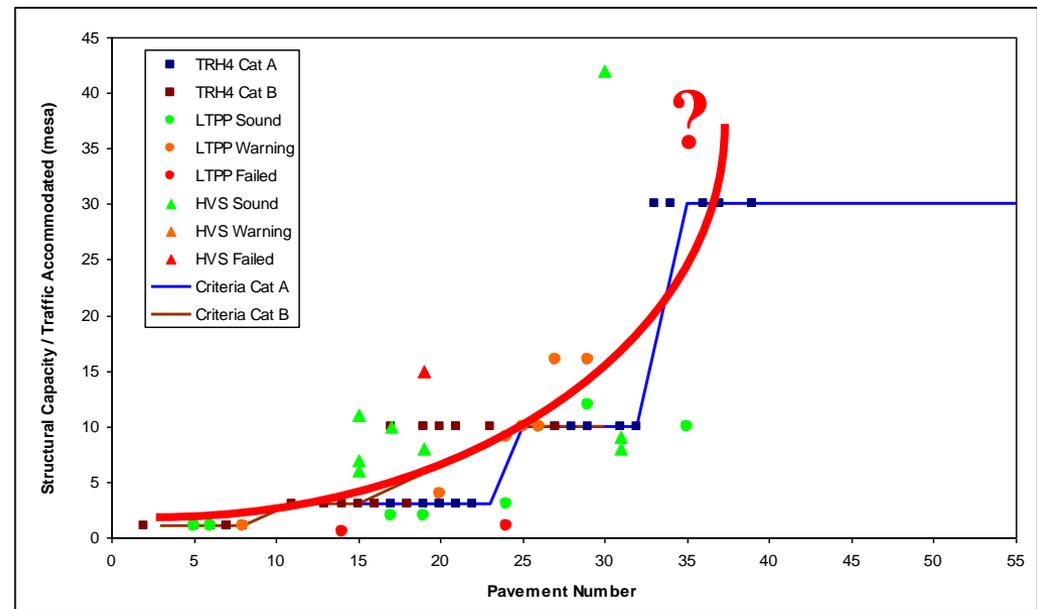
- **Frontier Curve**
  - "Segmented" function, needs "smoothing"
  - Conservative (calibrated: warning & TRH4)
  - Update 18/21 LTPP BSM sections (warning)
  - PPIS Sections of SANRAL: use some of 40
 - Toll concession sections?
- **Update (2016)**
  - Currently available in Rubicon Toolbox

BSM Design for Max Rut Depth
(same principle as Granular Design)

Mechanistic Analysis

HMA

BSM1

CTSB

SG

σ_1

σ_3
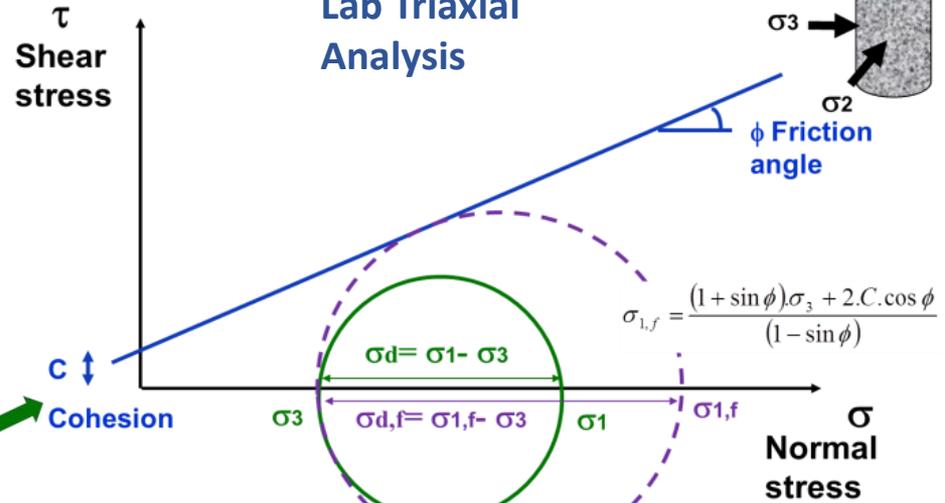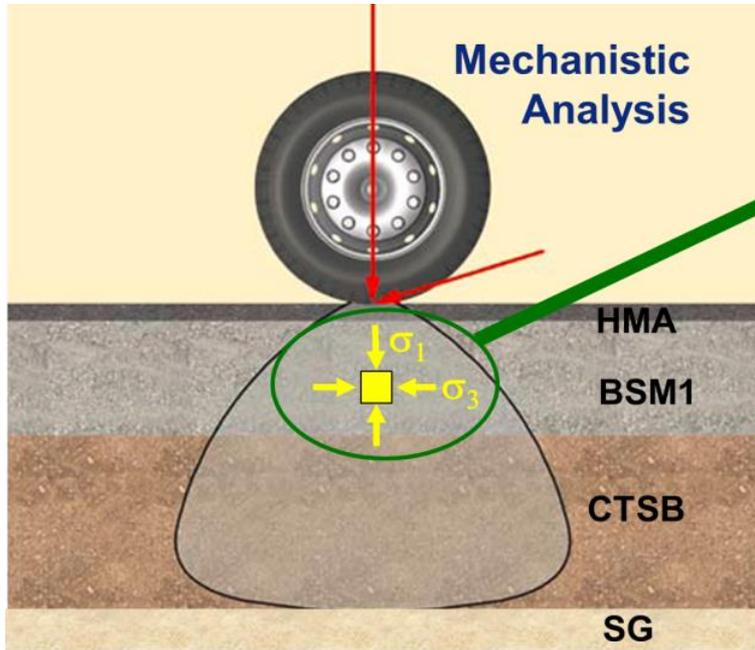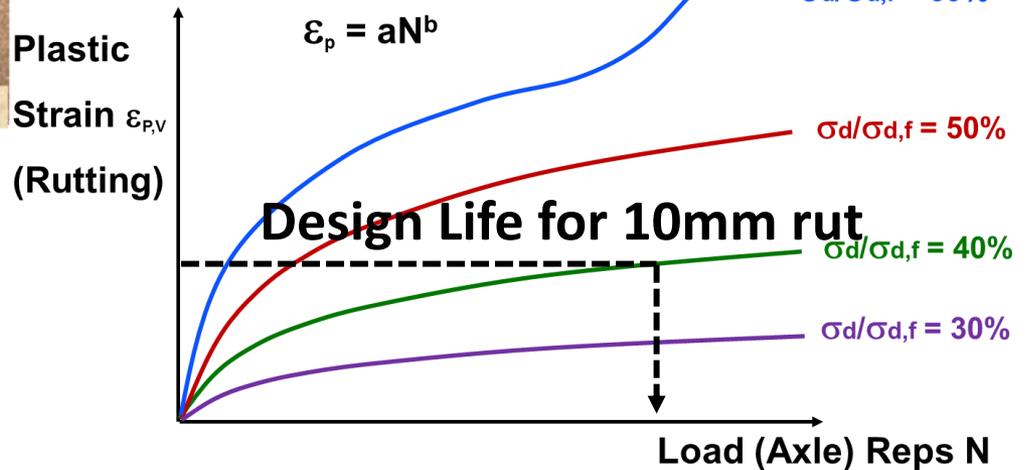
Permanent deformation (rutting) design for granular material

Lab Triaxial Analysis

τ **Shear stress**

ϕ **Friction angle**

σ_1

σ_3

σ_2

C $\updownarrow$ **Cohesion**

$$\sigma_{1,f} = \frac{(1+\sin\phi).\sigma_3 + 2.C.\cos\phi}{(1-\sin\phi)}$$

$\sigma_d = \sigma_1 - \sigma_3$

σ_3 $\sigma_{d,f} = \sigma_{1,f} - \sigma_3$ σ_1 $\sigma_{1,f}$

σ **Normal stress**

Stress Ratio = $\sigma_d / \sigma_{d,f}$

Plastic Strain $\varepsilon_{P,V}$ (Rutting)

$\varepsilon_p = aN^b$

$\sigma_d/\sigma_{d,f} = 60\%$

$\sigma_d/\sigma_{d,f} = 50\%$

Design Life for 10mm rut $\sigma_d/\sigma_{d,f} = 40\%$

$\sigma_d/\sigma_{d,f} = 30\%$

Load (Axle) Reps N

Design Function for BSM

P_mod = % Mod.AASHTO

Plastic Strain % (a/b)

a

b
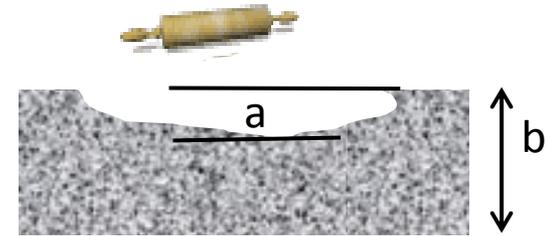
$$logN = A - B.DSR^3 + C.Pmod.RetC + D.PS$$

Deviator Stress Ratio
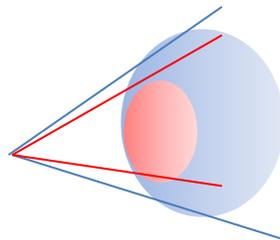
DSR power	Slope	Intercept	R^2
2	1.025	-0.5945	0.819
3	1.001	1.0572	0.927
4	1.1296	6.9172	0.355

Retained Cohesion

14 LTPP Pavement Structures and Plastic Strains

| Road	BSM thickness (mm)	BSM PS allocation (%)
MR27	100	55
MR504(A)	175	55
MR504(B)	175	55
N1-1	100	55
N1-13	150	50
N1-13 SB	100	35
N1-14	150	55
N2-16	140	70
N2-20	180	55
N4-1	170	70
N4-5X	150	65
N11-8	280	70
N12-19(3)	100	55
N12-19(4)	135	60
P243-1	250	70

$$\epsilon_p = A . \left(\frac{N}{1000} \right)^{B}$$

$$N = 1000 . \left(\frac{\epsilon_p}{A} \right)^{\frac{1}{B}}$$

Influence of RetC and Plastic Strain

Stellenbosch Univ: Bierman, 2017
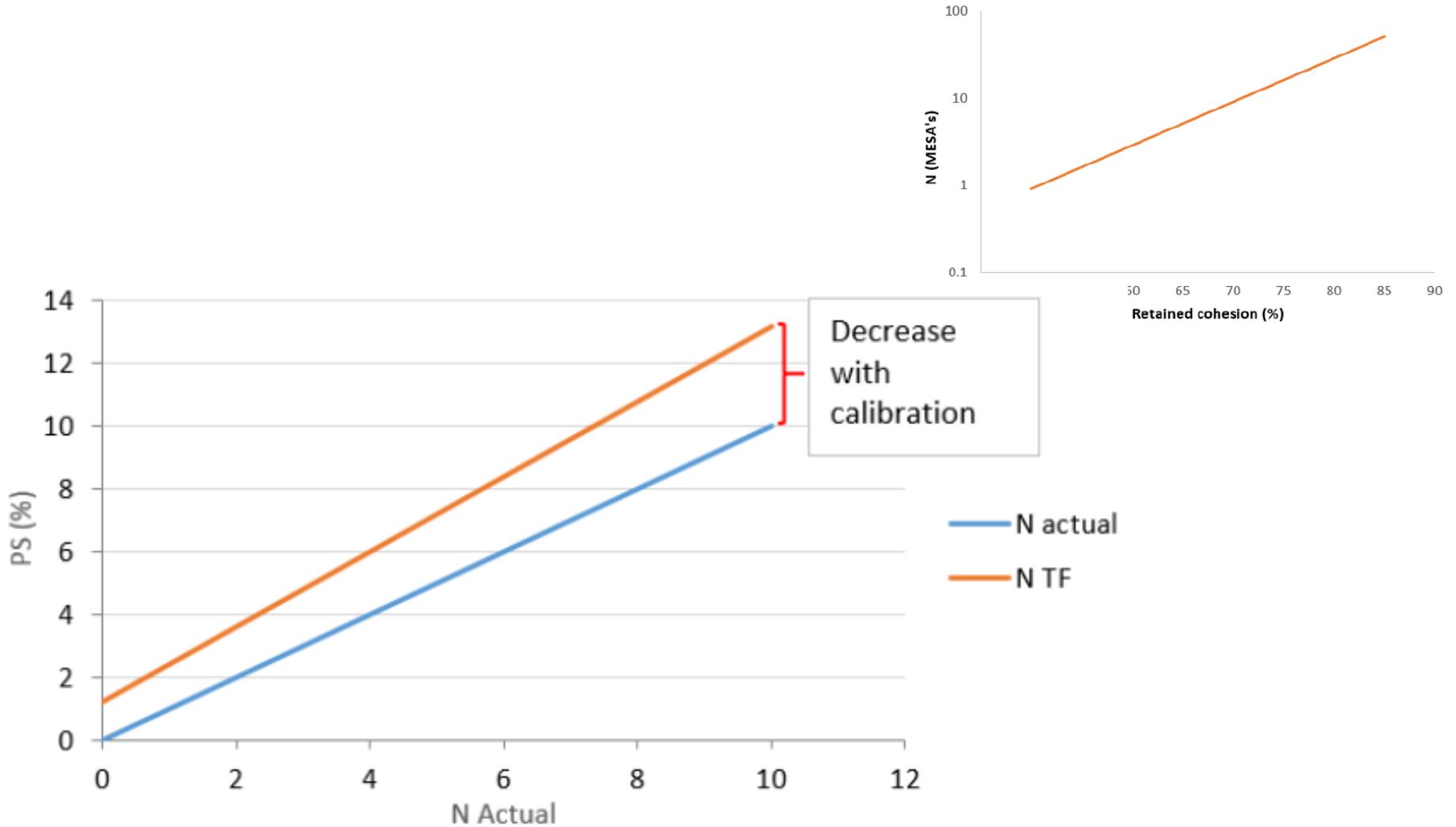
Mr of BSM base for LTPP Sections

Stellenbosch Univ: Bierman, 2017
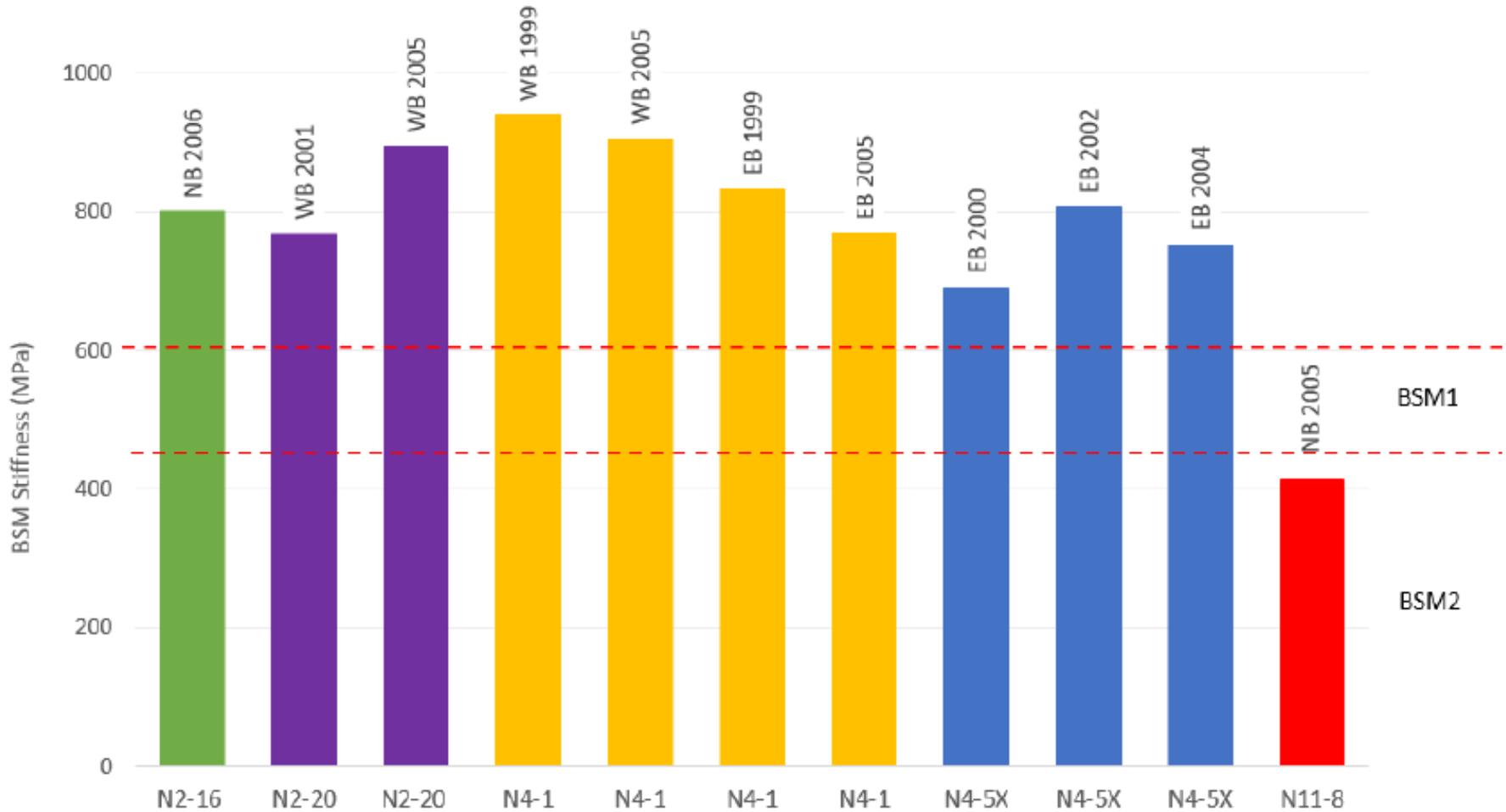
Transfer Function Calibration ito Reliability
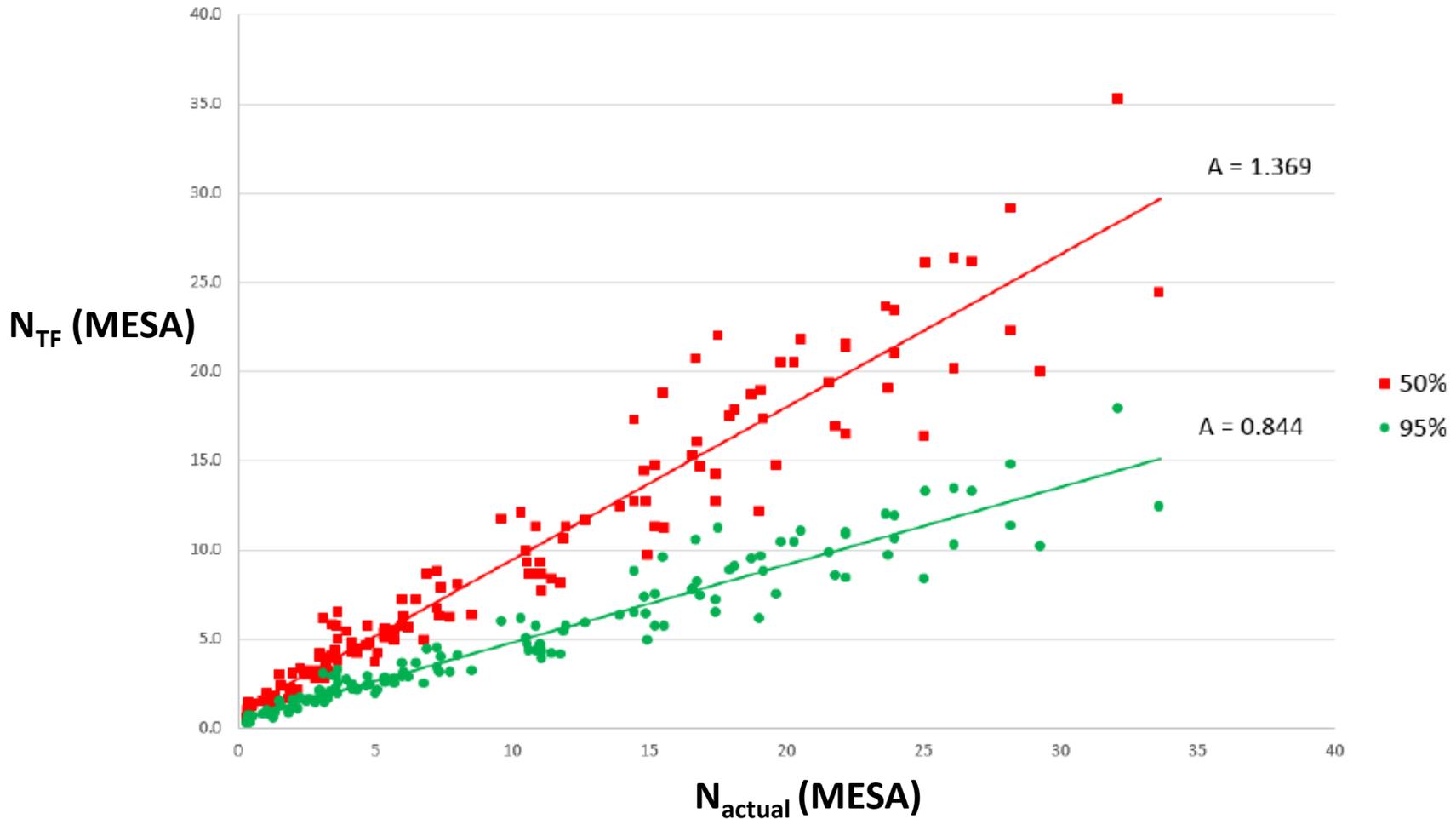
N_{TF} (MESA)

N_{actual} (MESA)

A = 1.369

A = 0.844

■ 50%

● 95%

Stellenbosch Univ: Bierman, 2017

Design Comparison: Typical Structures[1]

Legend:
- 3 (80 kN)
- 3 (100 kN)

Structure layers:
- Seal
- 200 BSM1
- 250 CTSB C3
- ∞ SG 100 MPa

Stellenbosch Univ: Bierman, 2017

Design Comparison: Typical Structures$_2$

Stellenbosch Univ: Bierman, 2017
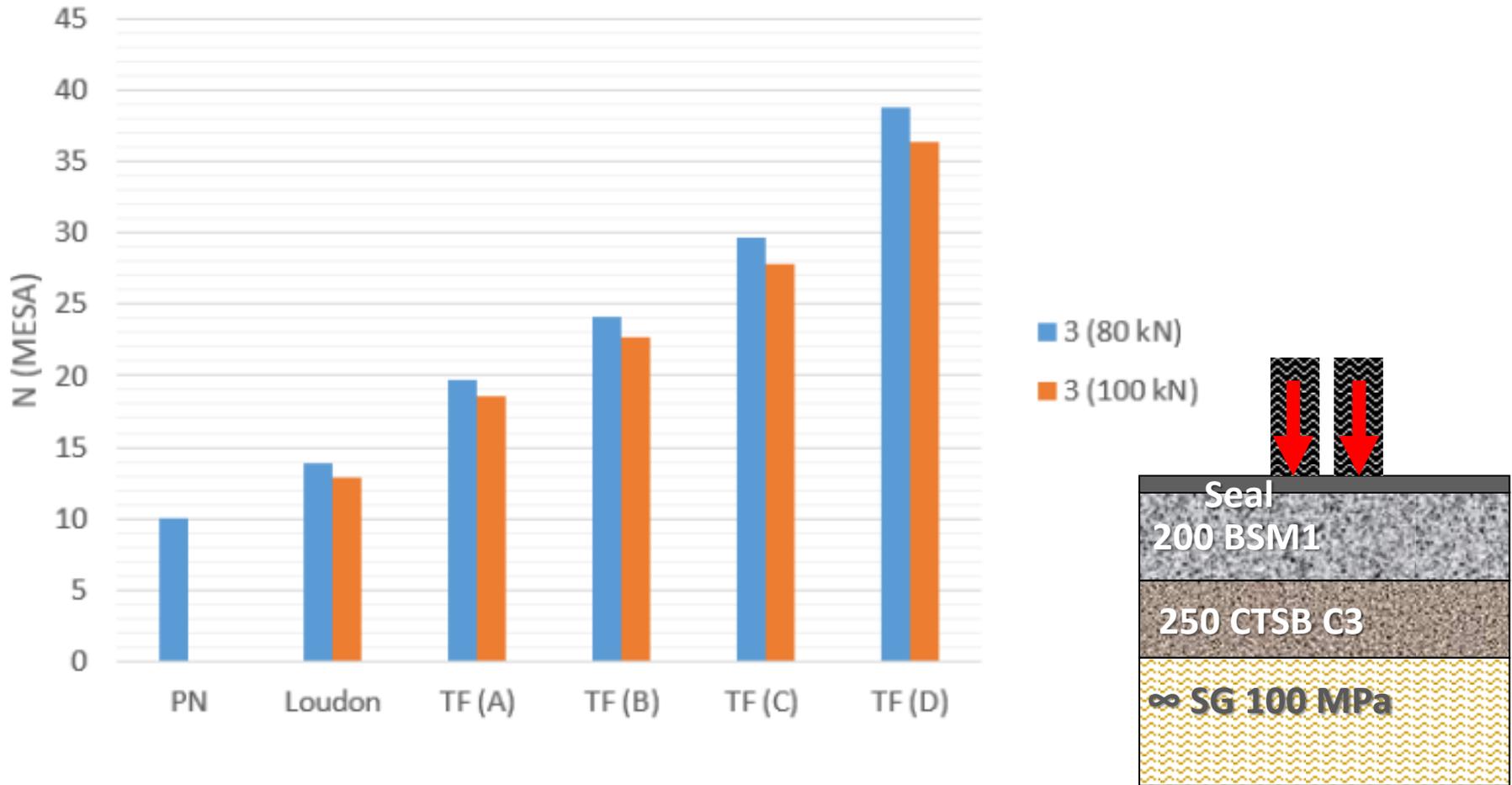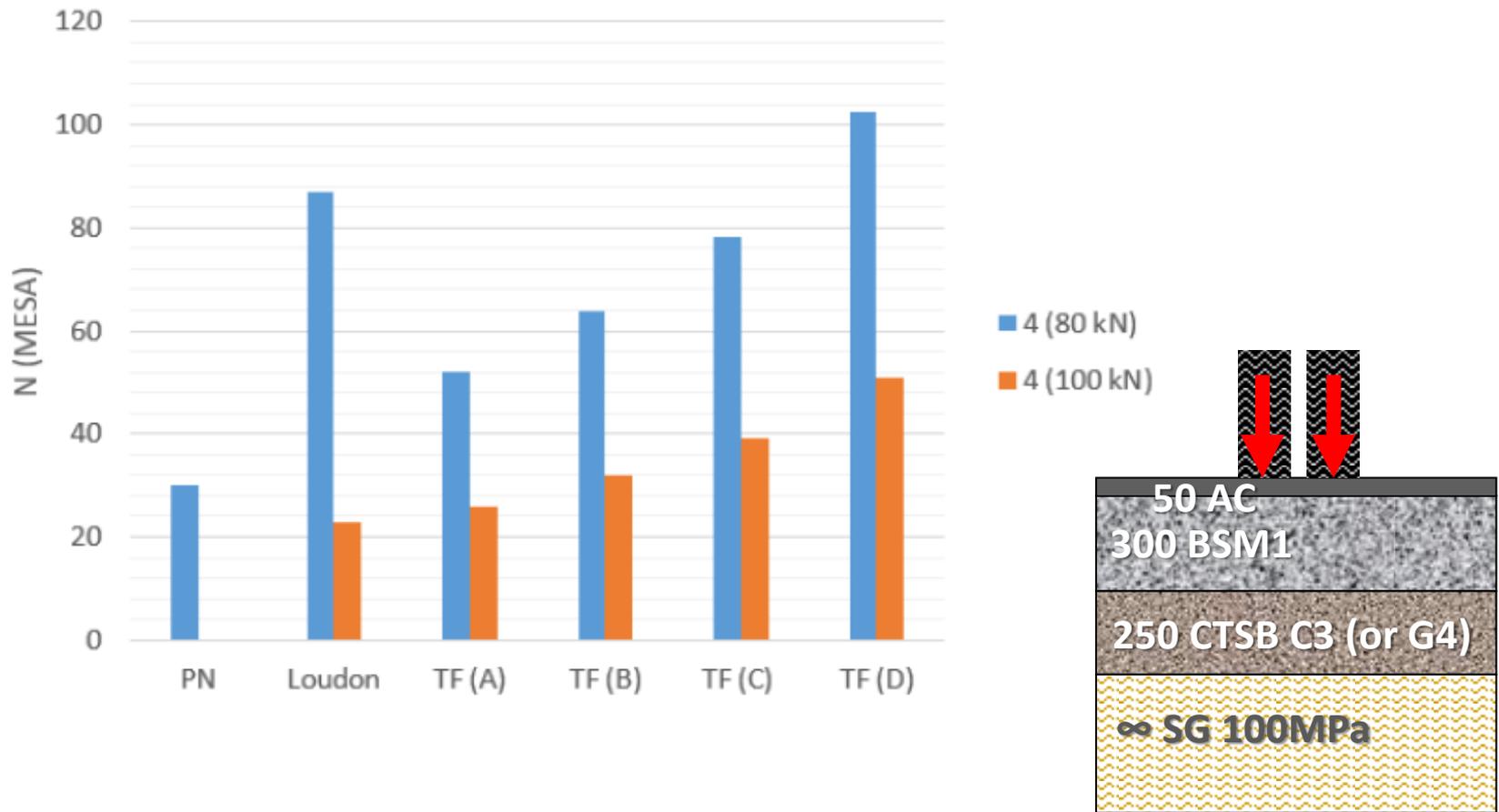
Conclusions

- **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)**

Stellenbosch
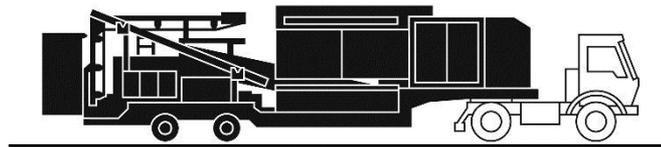
The sky's the limit!

Thank you!