

RPF November 2010: Progress Report on the SAPDM

ME design of Flexible Pavements:
**Update of the ME design method and
revision of *Me* - PADS®**

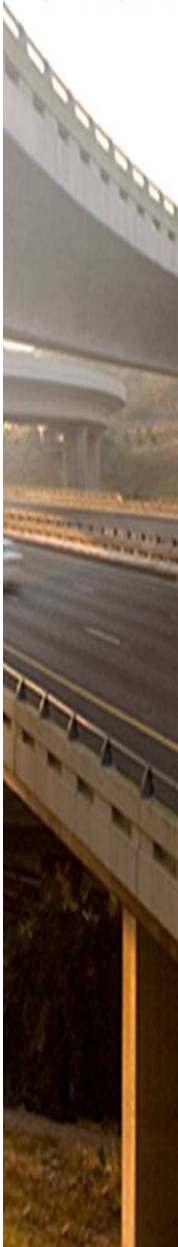
H L Theyse

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Background

- TRH4 revision 1994-95
 - Use existing research from 1970s to late 1980s to update the mechanistic-empirical design method for flexible pavements
 - Summary published at TRB in 1996
- Late 1990s, early 2000s implementation in software packages
 - Me*-PADS[®], Rubicon
 - More users – more questions – less answers

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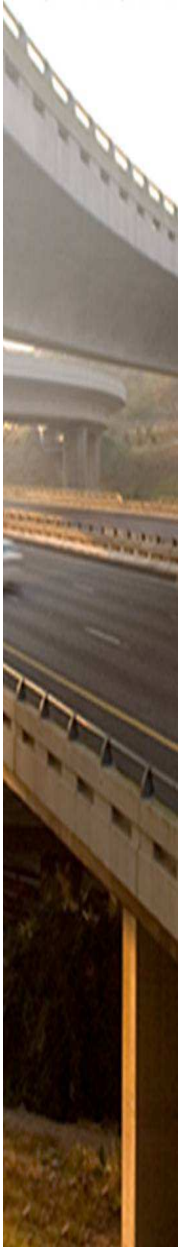


Background (continued)

- CAPSA'04
 - Jooste highlighted problems especially with models used for unbound material
 - Some research already initiated at CSIR
- RPF task group 2005
 - Framework for revision of the design method
 - SANRAL stepped forward with funding
- CAPSA'07
 - Research plan presented – Godzilla was born

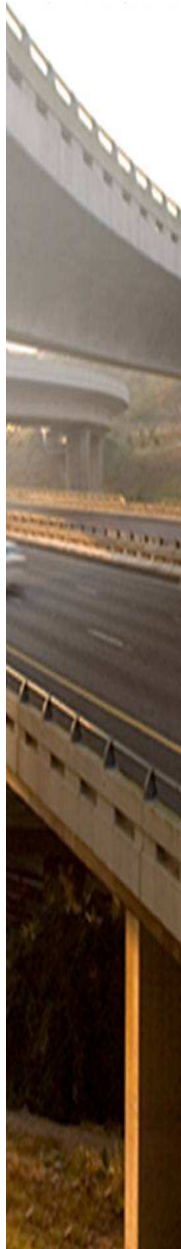
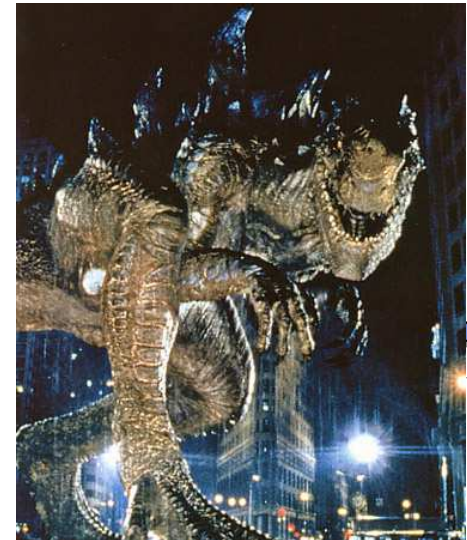


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Current status

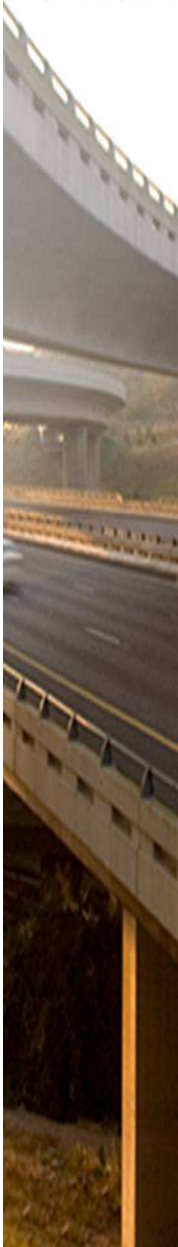
- SANRAL SAPDM project started in 2008
 - Godzilla alive and well
 - Some progress made, especially on modelling unbound material
- CSIR software
 - Time for an official update of the ME design method for flexible pavements
 - Deliver update in *Me-PADS*®
 - Target for launch – CAPSA'11
 - Only an interim solution
 - Final solution under SANRAL project



Planned changes

- HMA fatigue
 - Unchanged (for now)
- Unbound base and subbase layers
 - Effective stress analysis
 - Shear strength related to engineering properties
 - New plastic strain damage model
- Stabilised layers
 - Cemented
 - Effective fatigue damage model
 - Crushing failure damage model
 - New shear strength properties with plastic strain damage model

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Planned changes (continued)

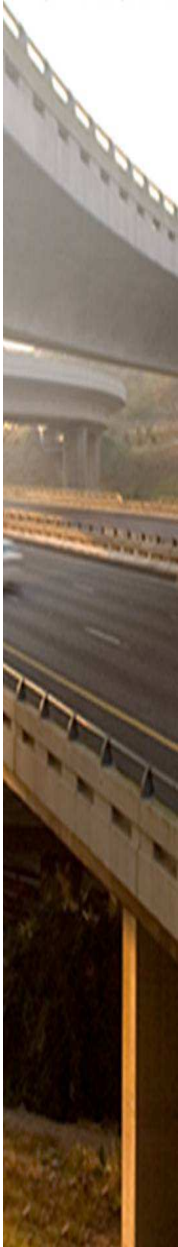
- Stabilised layers

Foam and emulsion

- Effective fatigue
- Plastic strain damage models



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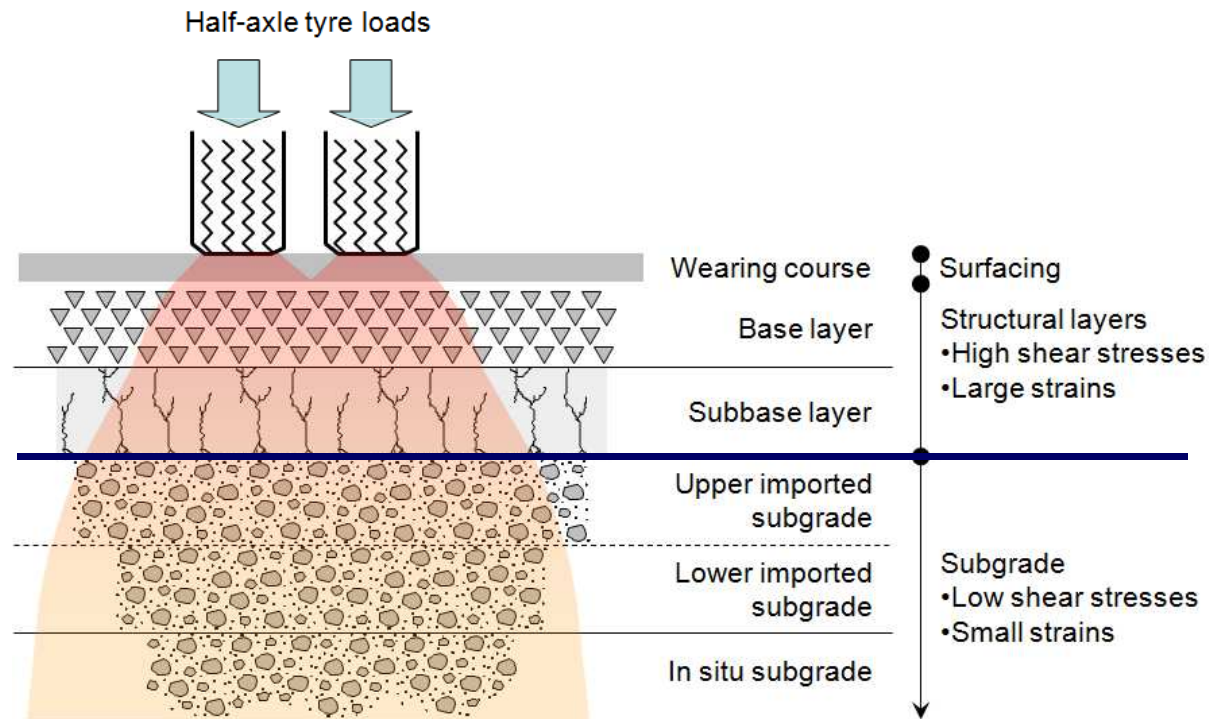


Planned changes (continued)

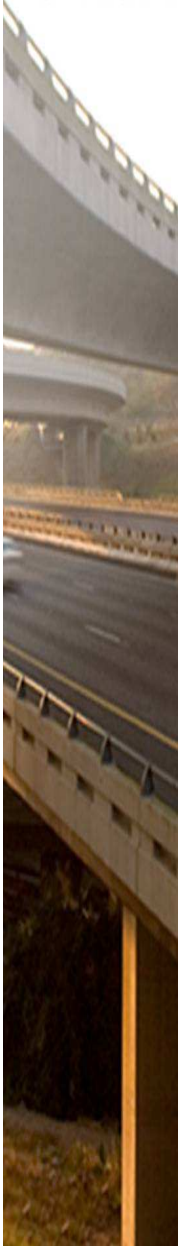
■ Subgrade

New critical parameter

New permanent deformation model



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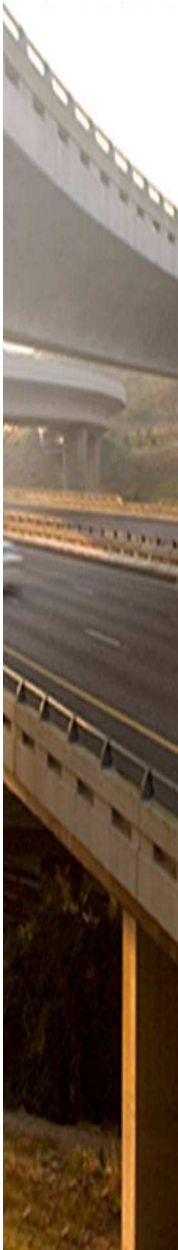
Unbound material: Subgrade

- Dormon and Metcalf vertical strain criterion

"First, calculation of vertical compressive strain in the subgrade for several different sections in the AASHO test indicated that a compressive strain of 6.5×10^{-4} was associated with 10^6 applications."

"The AASHO test also provided information by which the effects of different wheel loads of mixed traffic could be weighted. This relationship, shown in Figure 6 led to the development of the wheel load weighting curve in Figure 7. Subsequently, the compressive strain values previously assigned to different wheel loads were plotted according to their equivalent numbers as shown in Figure 5."

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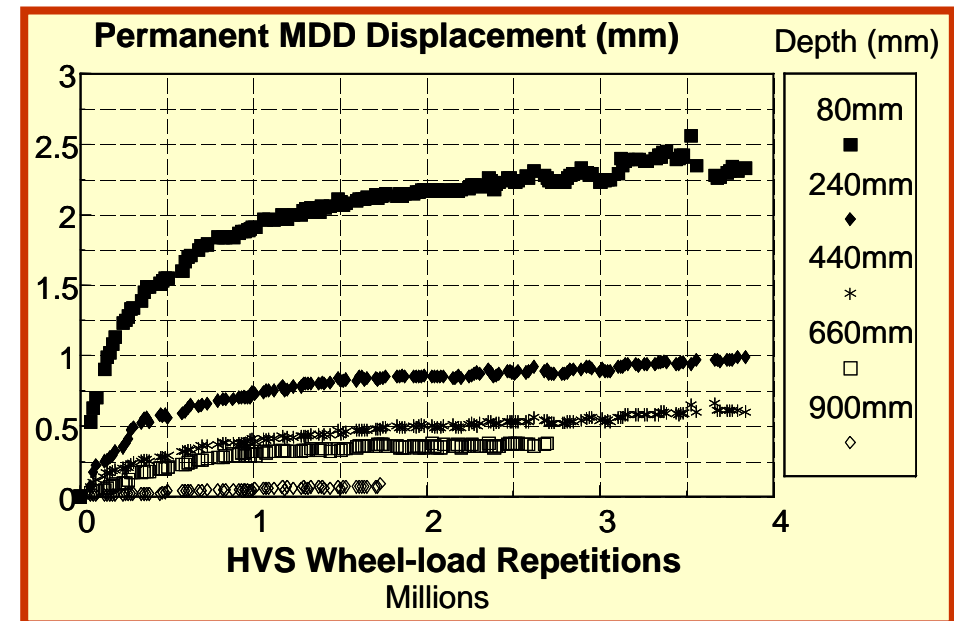
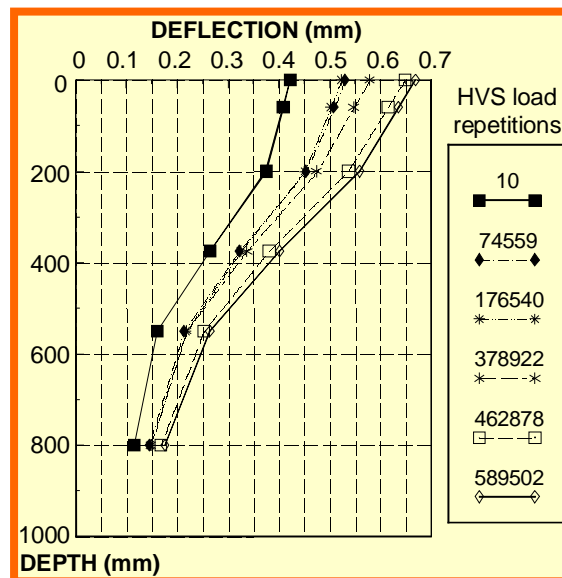
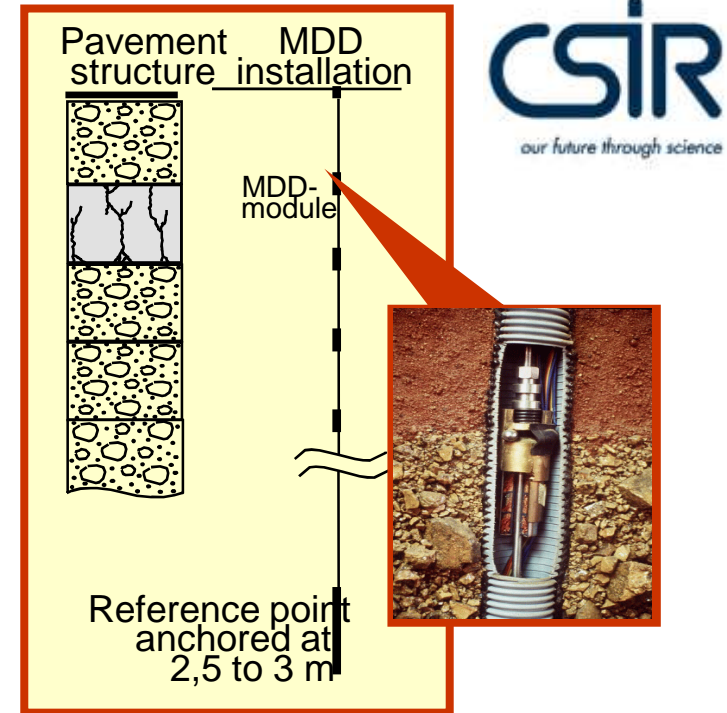


Unbound material: Subgrade

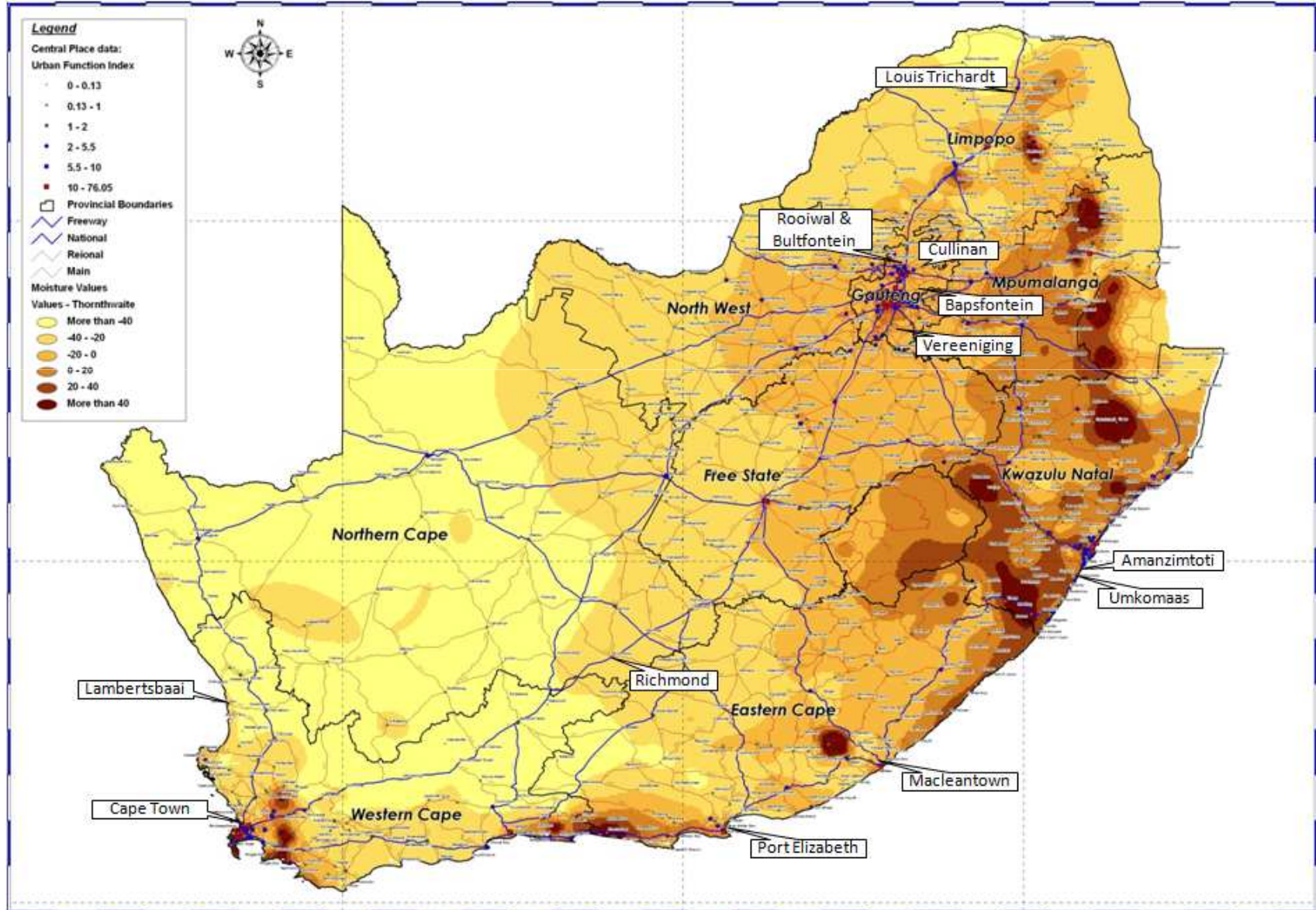
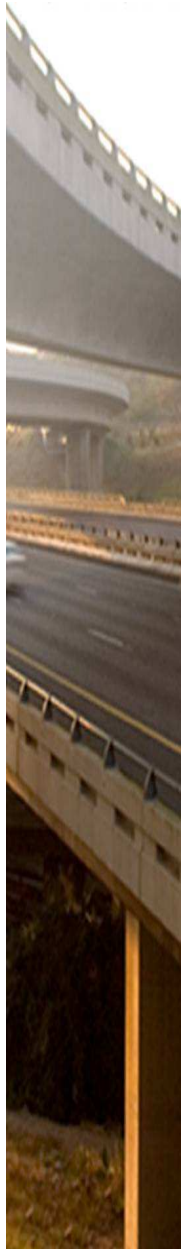
- MDD data from HVS tests

Elastic deflection

Permanent displacement

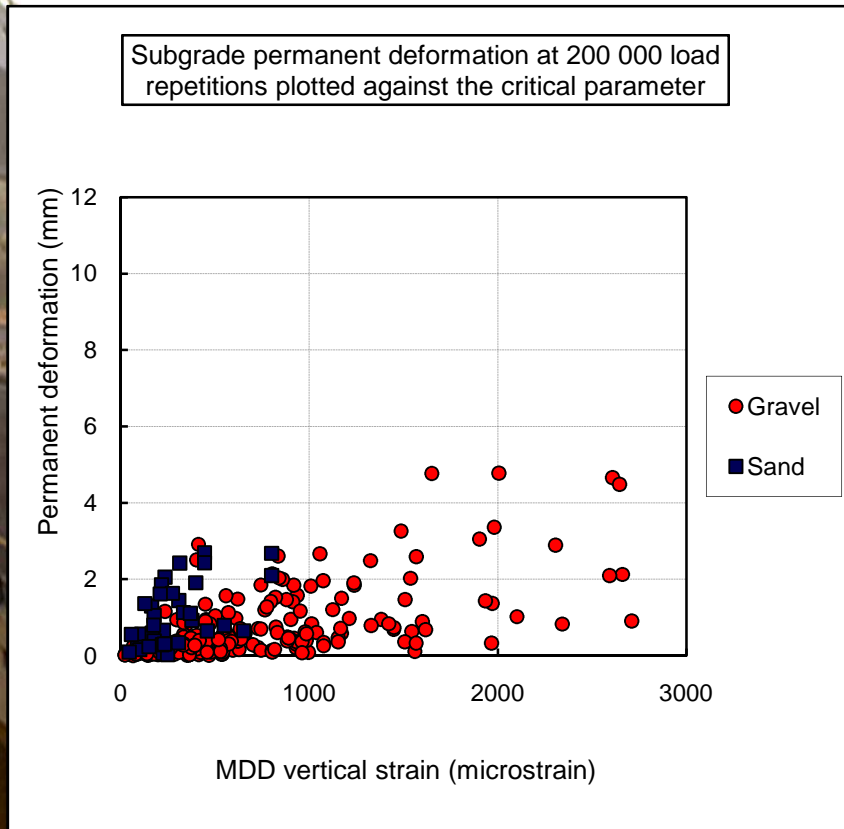


Unbound material: Subgrade

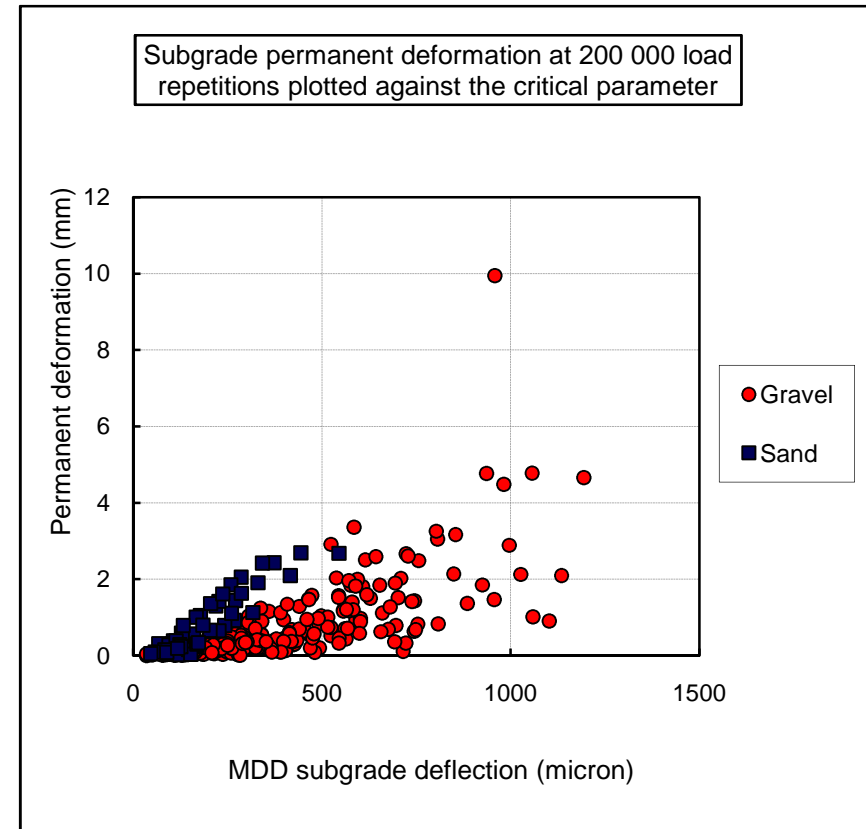


Unbound material: Subgrade PD

Vertical strain



Subgrade deflection

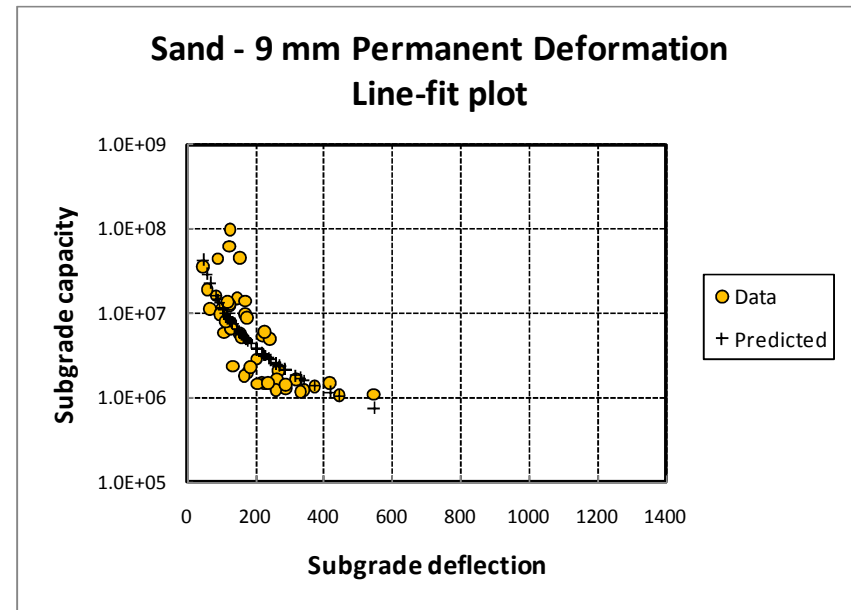
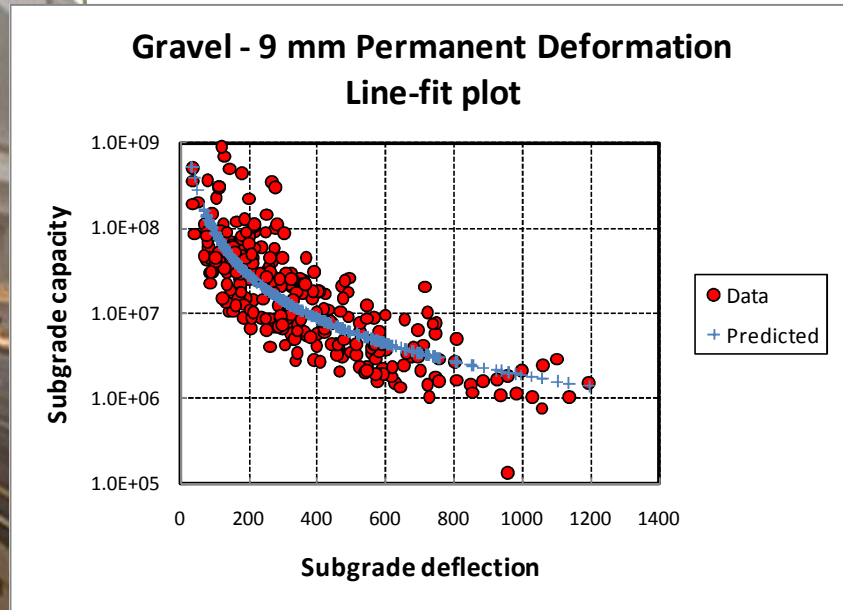


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Unbound material: Subgrade PD damage models

Gravel

Sand



$R^2 \sim 0.77$
 $SEE \sim 0.38$

$R^2 \sim 0.98$
 $SEE \sim 0.35$

$$\log N = I - m \log (SD) - offset$$

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Unbound material: Structural layers

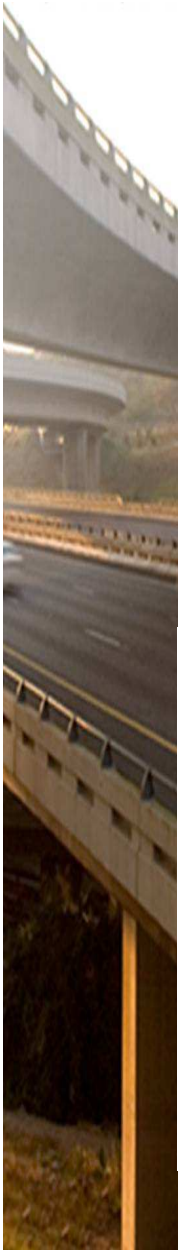
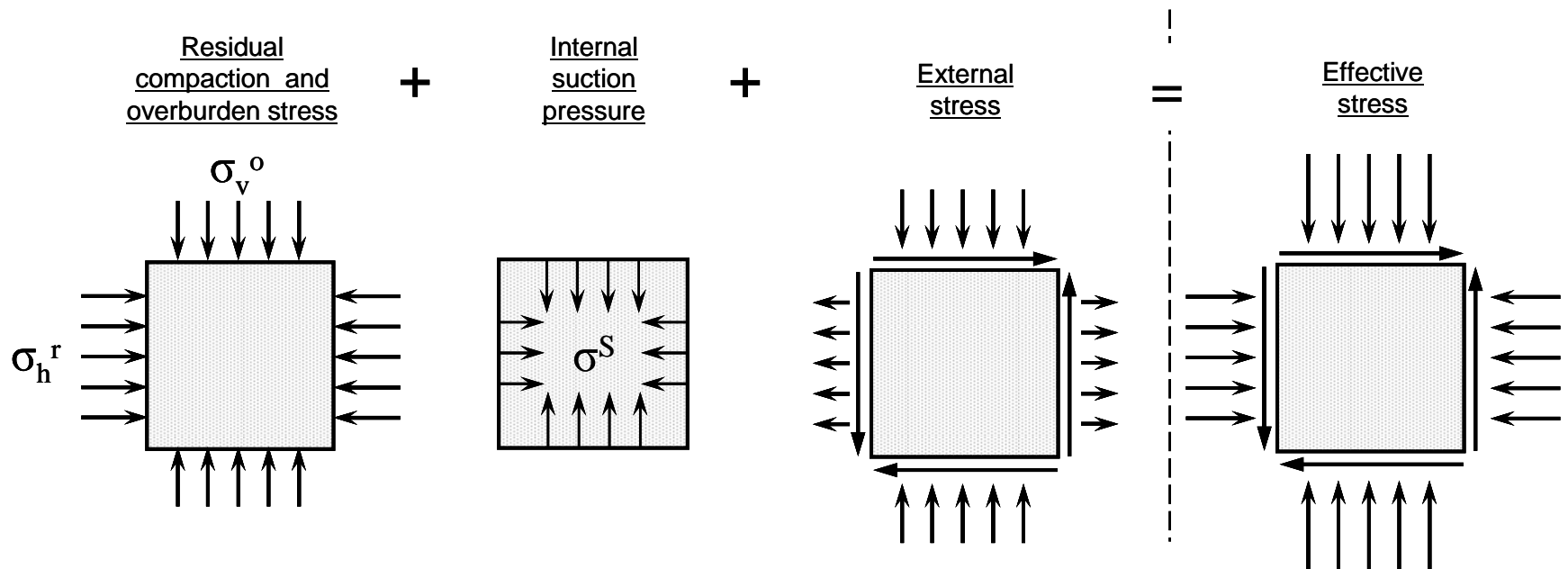
- Effective stress

Stress caused by the wheel-load

Suction pressure

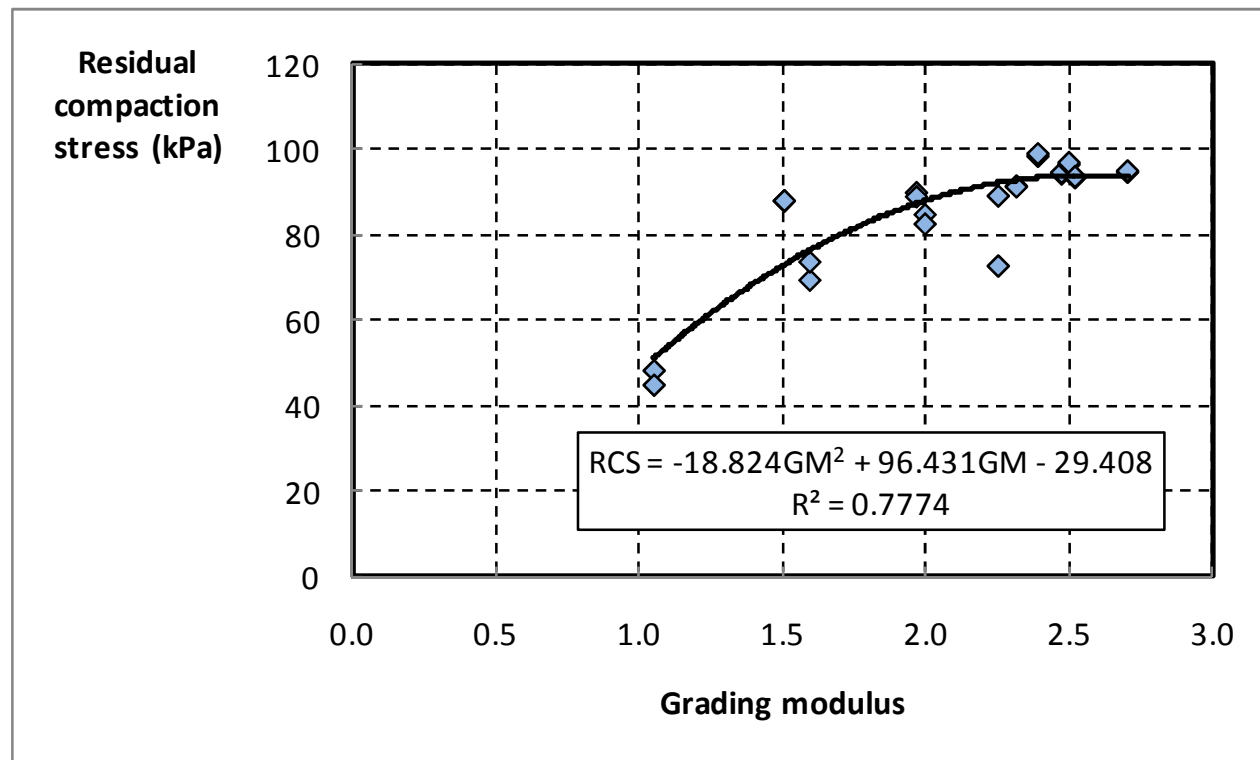
Overburden stress

Residual compaction stress

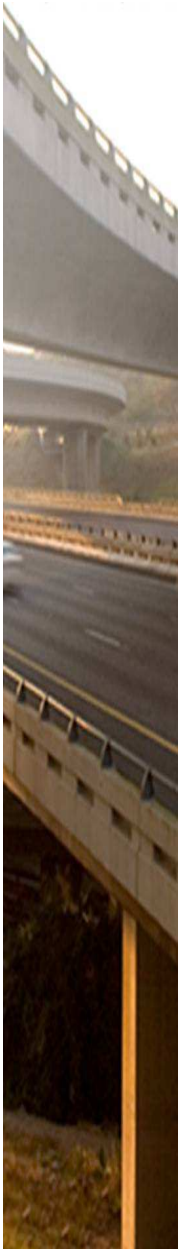


Unbound material: Residual compaction stress

- Observed by Dehlen (1959)
 - Static equilibrium model by Uzan (1980s)
- Design relationship derived from static equilibrium



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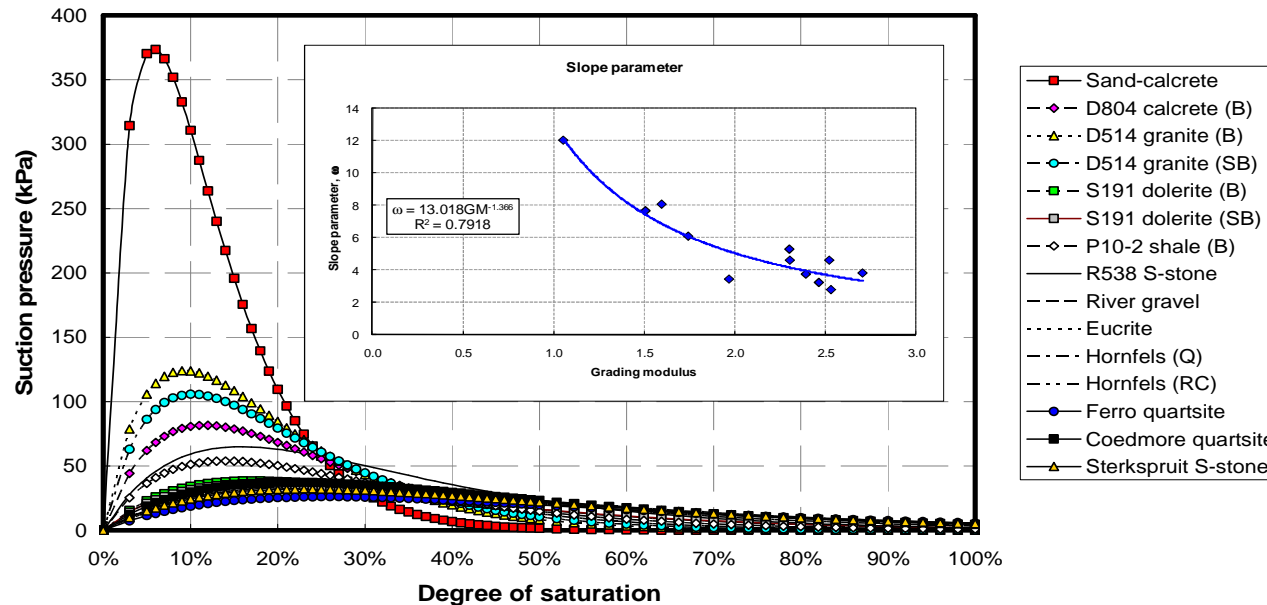


Unbound material: Suction pressure

- Suction pressure approximation model (Theyse, 2008)

Predictive design model – SANRAL project
Validation testing and recalibration - WITS

Predictive Suction Pressure Model



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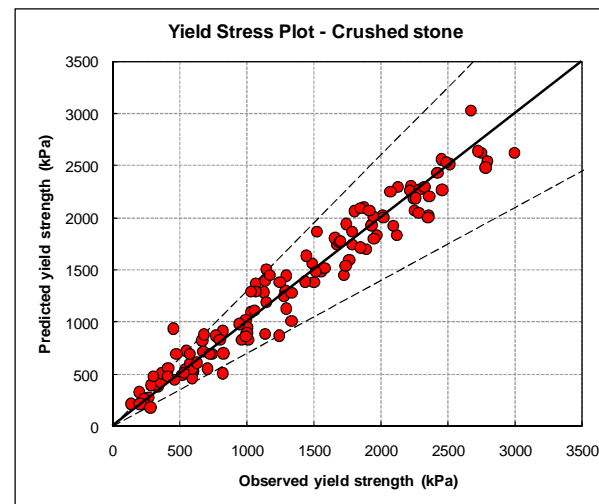
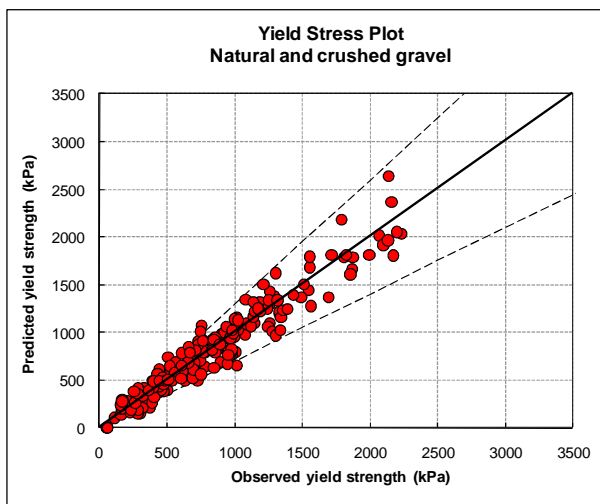
Unbound material: Shear strength model

- Data from Theyse, 2008
- Model developed under SANRAL project
- Predictive shear strength model

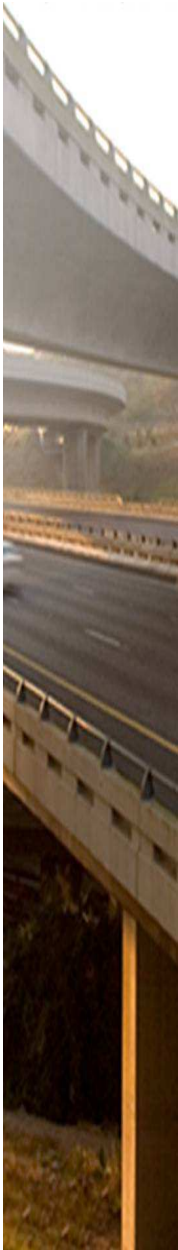
Grading modulus and $P_{0,075}$

Liquid limit

Linear shrinkage



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Unbound material: Plastic strain damage model

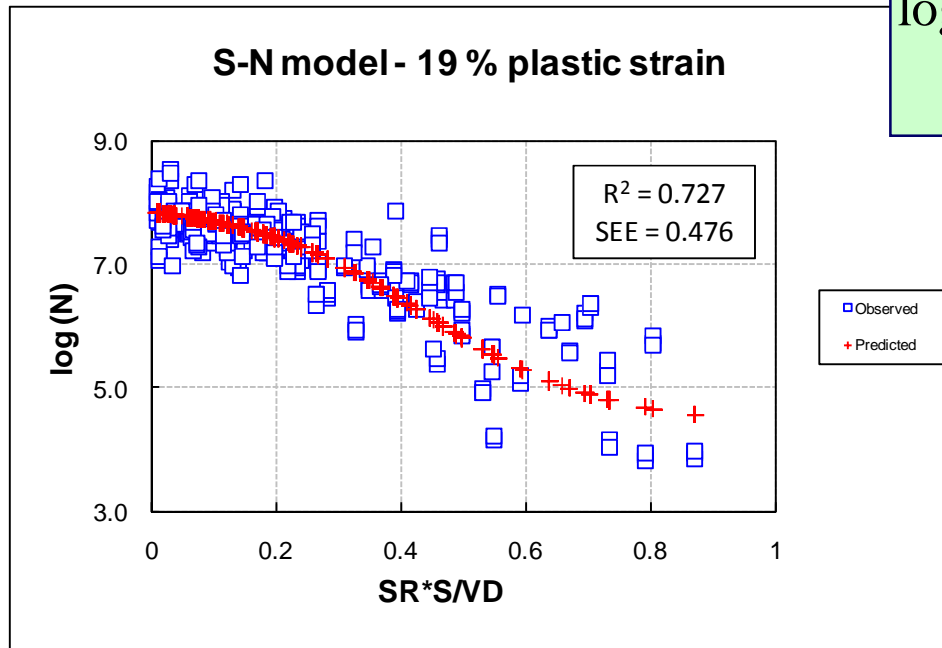
- Data from Theyse, 2008
- Model developed under SANRAL project

Stress Ratio

Volumetric density

Degree of saturation

$$\log N = I_0 - \frac{I_1 - I_0}{1 + I_0/I_1 e^{7 \left[\frac{S}{VD} (SR) - 0.35 \right]}}$$



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Software implementation

M G1 on C3 - arid - coarse 37,5 - ES100.mpd - mePADS

File

Pavement Structure Layer Input Loads and Evaluation Points Evaluation Points Contour Plot Profile Plot

Pavement
 Layer Input
 Layer 1
 Layer 2
 Layer 3
 Layer 4
 Wheel loads
 Evaluation Points
 Contour plot
 Profile plot

Main pavement layer: Layer 2
 Material code: G1

Engineering Information
 Layer classification: Base
 Density specification type: Volumetric
 Density specification (%): 86

Compaction information
 Apparent relative density: 2.836
 Mod AASTO max. dry density: 2300
 Optimum compaction moisture content (%): 5

Field conditions
 Density: Dry density (kg/m³): 2438.96, VD: 86
 Moisture content: EMC %: 2.20520576433, S: 38.4172046499

Grading and Atterberg indicators

Sieve Size	% Passing
63	100.00
53	100.00
37.5	100.00
26.5	84.00
19	71.00
13.2	59.00
4.75	36.00
2	23.00
0.425	11.00
0.075	4.00

 Liquid limit: 25
 Plastic limit: 21
 Plasticity index: 4
 Linear shrinkage: 4
 Grading modulus: 2.62

Resilient respond parameters

	Phase 1	Phase 2
Resilient modulus (MPa)	450	225
Poisson's Ratio	0.35	0.35

Mohr Coulomb shear strength parameters
 Field conditions
 VD: 86, Cohesion (kPa): 88.647976295
 S: 38.4172046499, Friction angle (°): 54.809976168

Update plot

Damage models
 Plastic strain

$$\log N = I_0 - \frac{I_1 - I_0}{1 + I_0/I_1 e^{7 \left[\frac{S}{VD} (SR) - 0.35 \right]}}$$
 Define

Calculate

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Closing statements

- ME design inputs for unbound structural layers

Input data

- Resilient response parameters
- Grading, Atterberg limits, density, moisture content

Model not perfect but much better than previous model

- Separate models required for natural gravel

- Subgrade design

Depends on resilient response parameters

Working on recommended M_r values

- Models for HMA and stabilised material being developed/refined under SANRAL project

- How do you get your hands on the new method?

Me-PADS® launch at CAPSA'11

After the launch SAMDM'96 will be declared dead and no longer valid

Software used to be for free, probably still will be BUT

- Only available at CSIR/PMC course presented annually

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