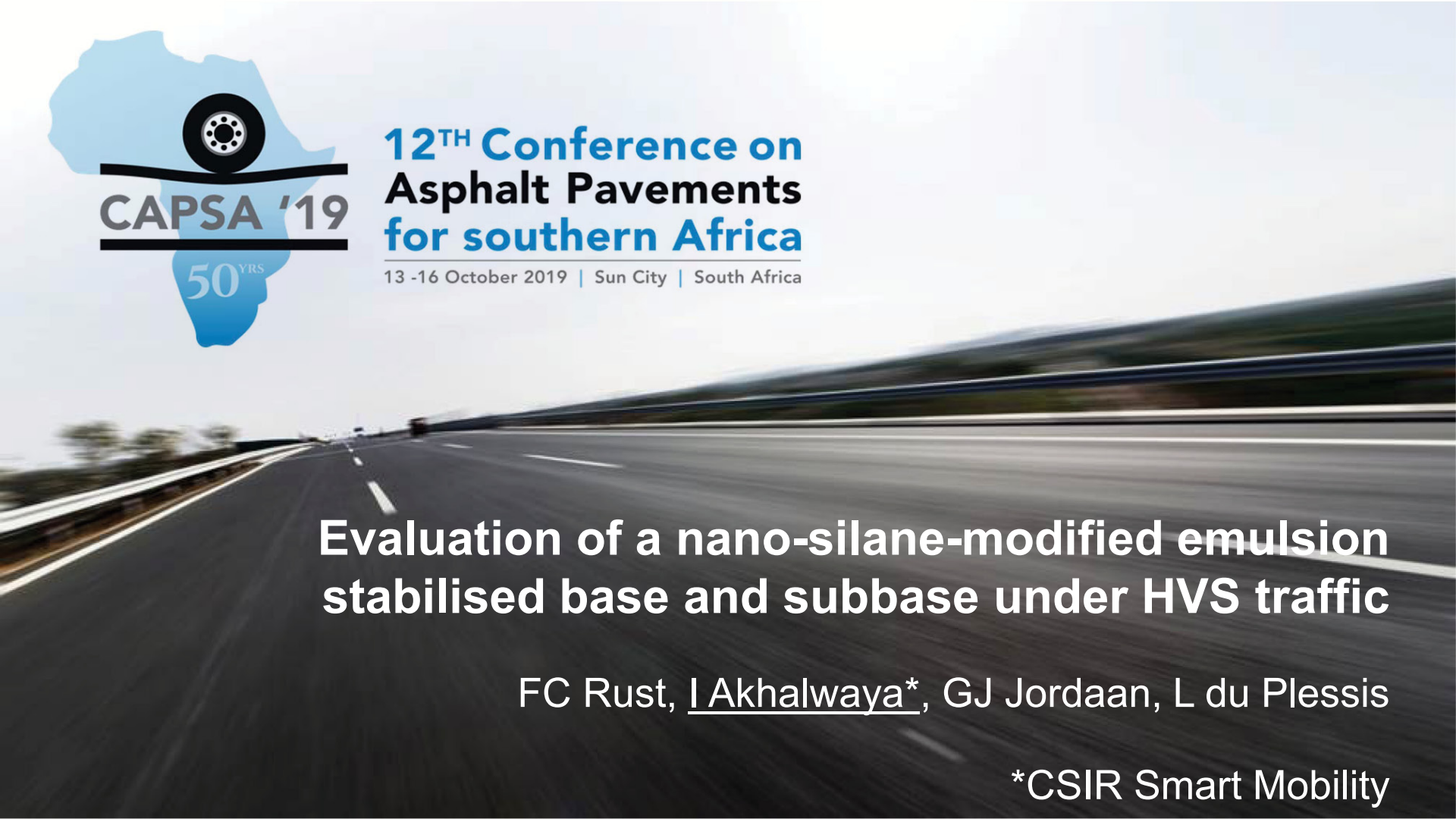

Evaluation of a nano-silane-modified emulsion stabilised base and subbase under HVS traffic

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*CSIR Smart Mobility

INTRODUCTION AND PURPOSE OF THE PAPER

Nano-silane-modified emulsions provide an opportunity for the cost-effective upgrading of roads using marginal materials

Demonstration Sections in Gauteng

- D1884 (Meyerton) – ES3 and ES1 designs
- K46 (Diepsloot – William Nicol) – ES10 design

CSIR Research Programme

- Desktop studies, laboratory testing
- Accelerated Pavement Testing (APT)

Purpose of Paper

- First set of HVS results

CSIR Heavy Vehicle Simulator (HVS)

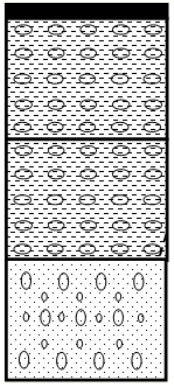
SITE LOCATION AND PAVEMENT STRUCTURE

Provincial Road D1884 in Meyerton

- Rehabilitation design traffic of 3 Million Equivalent Standard 80 kN Axle loads (ES3 DESIGN)

Insitu Materials

- G7/G8 material used for base and subbase
- High percentages of clay and mica (marginal)
- Successfully stabilised using an anionic nano-silane-modified emulsion (NME)

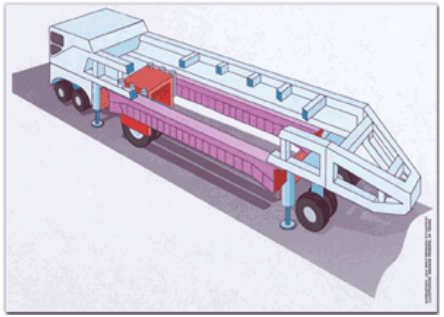


Alternative design

METHODOLOGY AND TESTING REGIME

CSIR D1884 HVS project

- 3 months of testing (October 2018 to January 2019)
- 24/7 testing regime
- Bi-directional and wandering traffic
- Wet testing included (significant rainfall also recorded)



Main objectives of the HVS project

- Performance evaluation of NME base and subbase materials
- Further proof testing of nanotechnology in South Africa
- Generate data to optimise preliminary design catalogues

LOAD APPLICATIONS TO HVS SECTION

D1884 HVS Test Plan:

- 321,350 repetitions of a 40 kN dual wheel load (80 kN axle load) in the dry state
- 372,600 repetitions of a 60 kN dual wheel load (120 kN axle load) in the dry state
- 96,882 repetitions of an 80 kN dual wheel load (160 kN axle load) in the dry state
- 155,649 repetitions of an 80 kN dual wheel load (160 kN axle load) in the wet state.

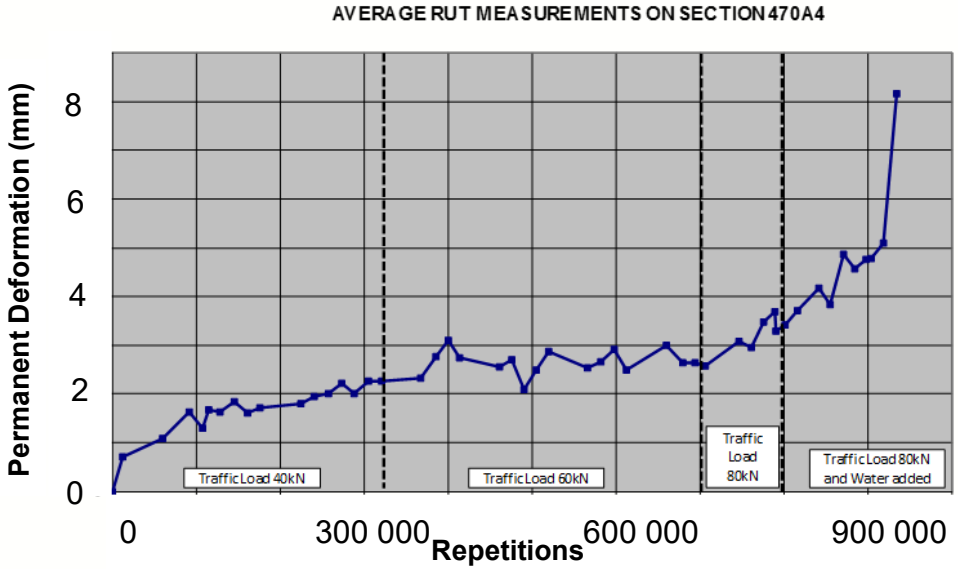
- Tyre pressure = 800 kPa

HVS RESULTS – RUT MEASUREMENTS

Measured with the CSIR's laser profilometer

Final average rut depth of total HVS section = 8 mm

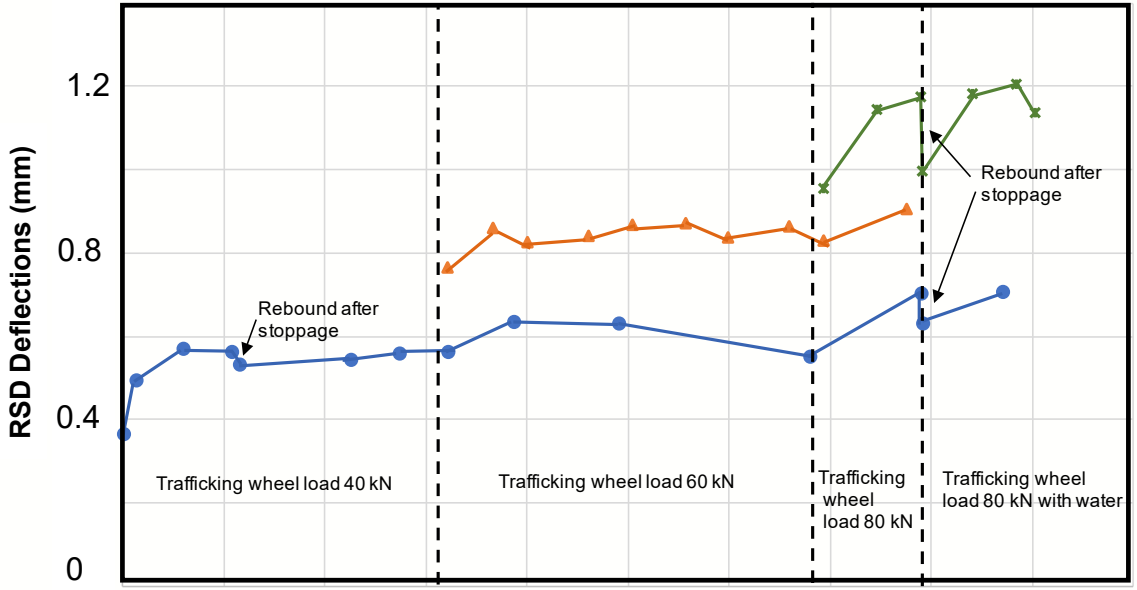
- 7 million E80s (d = 4.2)
- 3.5 million E80s (d = measured with HVS)



HVS RESULTS – ROAD SURFACE DEFLECTIONS

Measured with the CSIR's Road Surface Deflectometer (RSD)

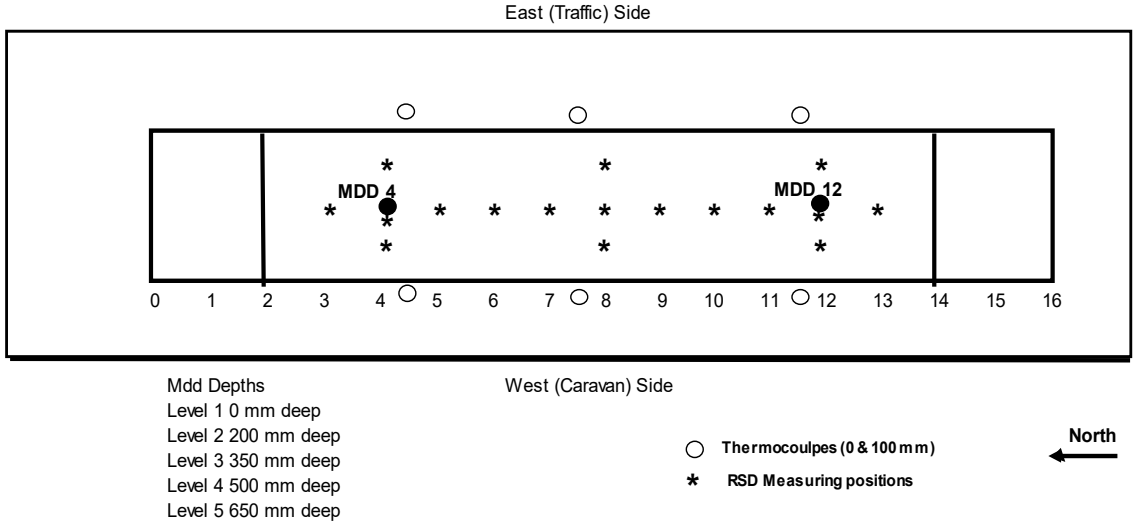
- Initial value of 0.36 mm
- Increased to 0.71 mm with a max of 0.89 mm (at 40 kN measuring load)



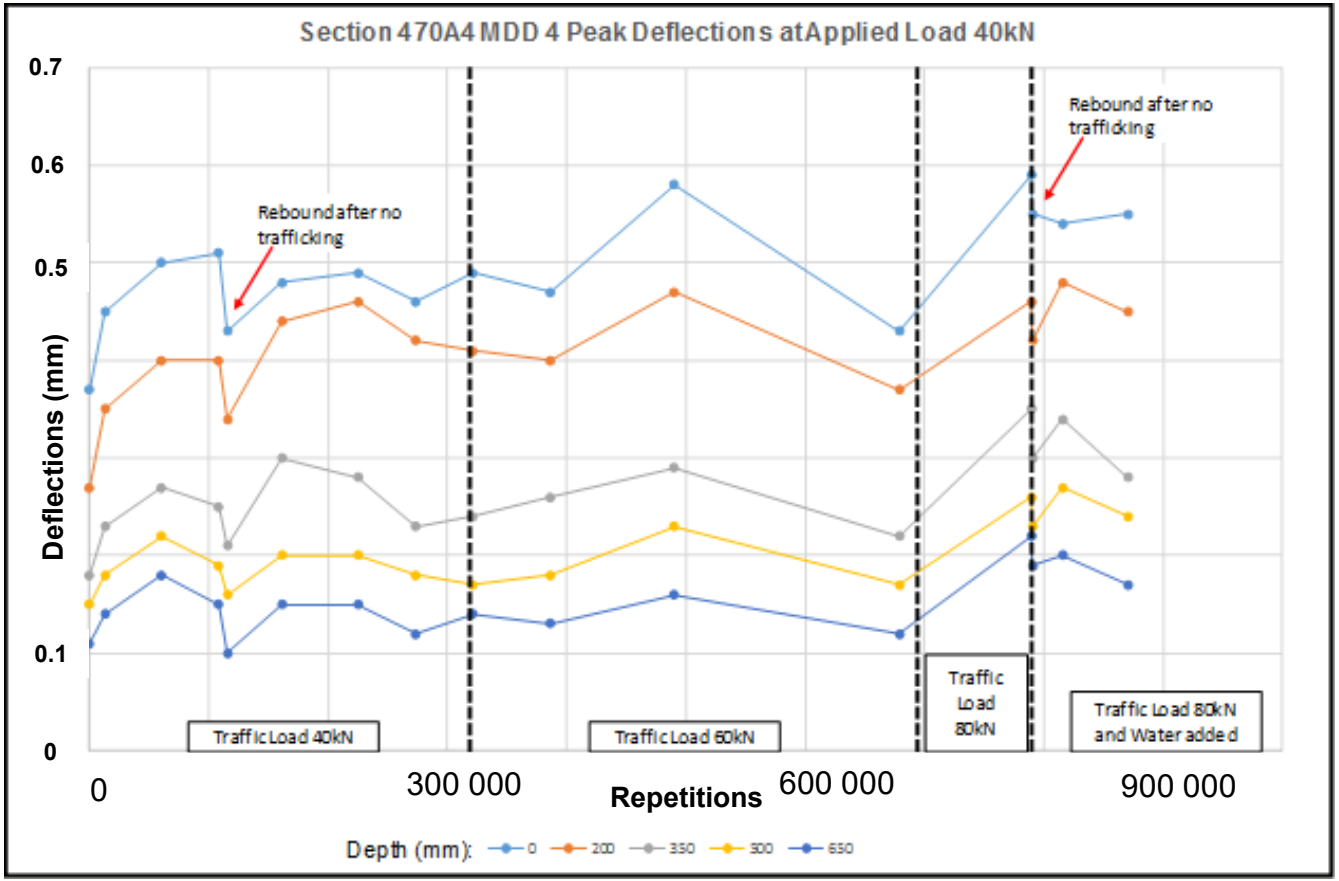
HVS RESULTS – PAVEMENT LAYER DEFLECTIONS

Measured with two CSIR Multi-Depth Deflectometers (MDD's)

LAYOUT OF SECTION 470A4

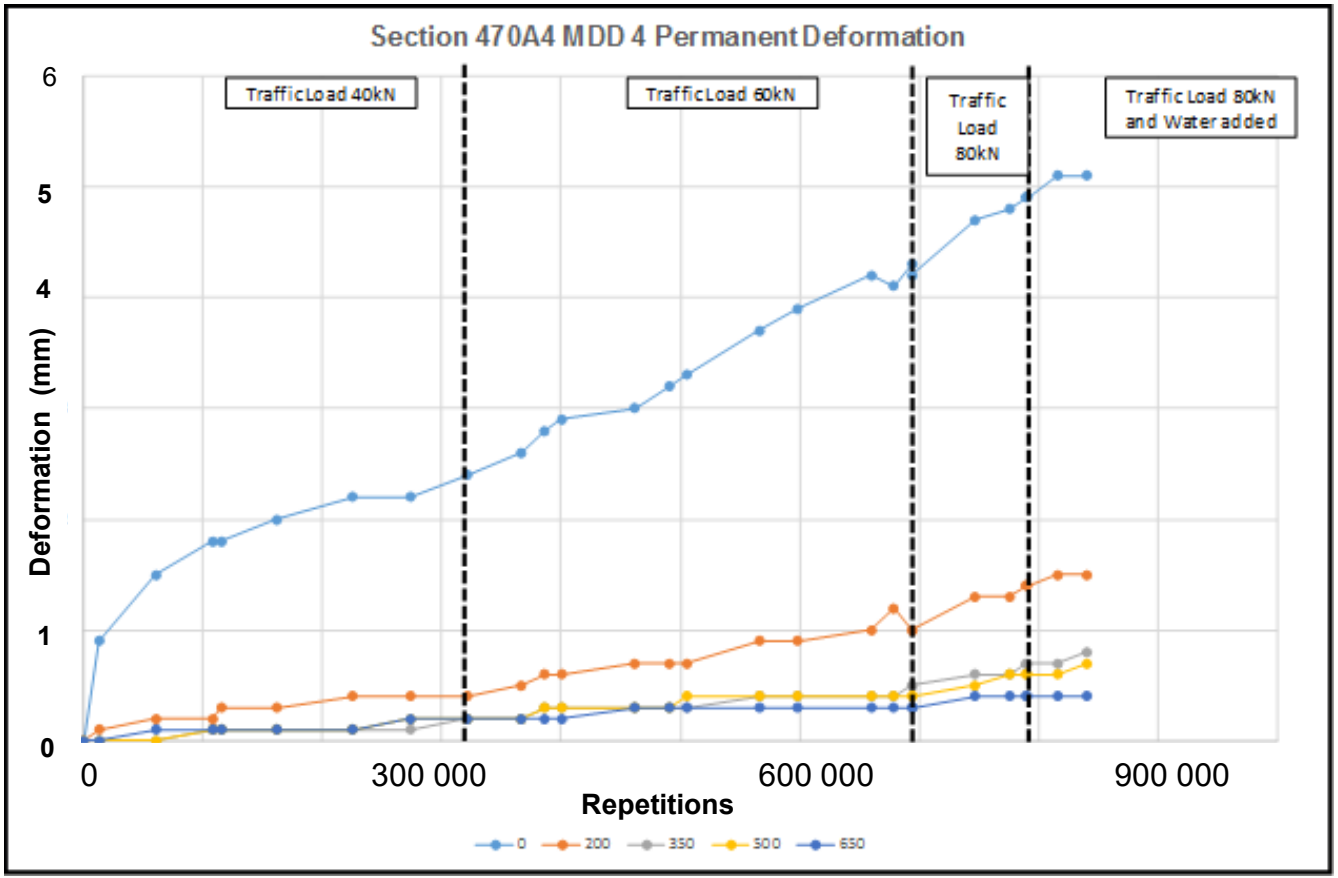


HVS RESULTS – MDD DEFLECTIONS



- Total deflection under the 40 kN wheel load = 0.59 mm
- At 490,000 repetitions, 0.11 mm came from the NME base and 0.18 mm came from the NME subbase

HVS RESULTS – MDD DEFLECTIONS



- Most of the permanent deformation from base layer
- Acceptable in terms of pavement design guidelines = 3.6 mm

COMPARISON TO D1884 LABORATORY RESULTS

Material	ITS_{dry} (kPa)	ITS_{wet} (kPa)	(ITS_{wet}/ITS_{dry})	UCS_{dry} (kPa)	UCS_{wet} (kPa)	(UCS_{dry}/UCS_{wet})
Base layer: 1.5% modified emulsion (1,5* liter / m^3)	**232**	**184**	**79%**	**2620**	**1865**	**71%**
Sub-base layer: 1.2% modified emulsion (1,5* liter / m^3)	**268**	**206**	**77%**	**4947**	**1670**	**34%**
Sub-base layer: 1.0% modified emulsion (1,5* liter / m^{3*})	**420**	**321**	**76%**	**4807**	**831**	**17%**

- Very high ITS values in line with previous findings for South African materials

DAMAGE COEFFICIENTS AND EQUIVALENT TRAFFIC

Wheel load (kN)	Total traffic repetitions	Repetitions for the slope calculation	Rut (mm)	d	E80s (HVS)	E80s (d = 4.2)
40	321,350	229,800	0.63	**1**	321,350	321,350
60	372,600	169,350	0.9	**1.63249**	722,287	2,045,626
80	96,882	83,500	1.1	**2.26461**	465,542	1,780,611
80 (wet)	155,649	133,400	4.738	**3.69547**	2,016,485	2,860,700
TOT E80s					**3,525,664**	**7,008,287**

- Difficult to conclude using only one HVS test
- Standard method used - rut rate (mm) per repetitions
- Low damage factors indicates NMEs may be relatively insensitive to overloading

PAVEMENT STRUCTURE MODULI

- Back-calculated using MDD data
- DCP testing also done inside and outside HVS section

	Moduli (Mpa)					
DEPTH	DCP outside section	DCP in section	MDD 4 Average	MDD4 range	MDD 12 Average	MDD 12 Range
Base	**252**	**309**	**173**	**69 - 797**	**127**	**71 - 214**
Subbase	**245**	**246**	**93**	**40 - 142**	**98**	**71 - 134**
350 - 500 mm deep	**145**	**193**	**154**	**75 - 316**	**174**	**82 - 606**
500 - 650 mm deep	**108**	**121**	**205**	**136 - 268**	**198**	**160 - 268**
550 - 800 mm deep	**99**	**220**				

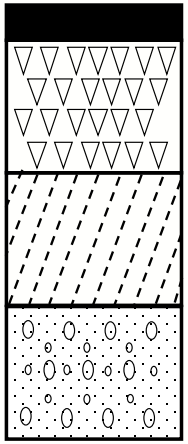
INTERPRETATION OF MODULI CALCULATIONS

	Average Calculated Moduli			
LAYER	MDD 4 Base layer	MDD 4 Subbase layer	MDD 12 Base layer	MDD 12 Subbase layer
Phase 1 up to 108,000 repetitions	**91**	**112**	**125**	**109**
Phase 2 from 108,000 to 679,000 repetitions	**258**	**81**	**139**	**97**
Phase 3 from 679,000 to 903,000 repetitions	**104**	**96**	**104**	**88**

Base Layer Interpretation

- Initial stiffening phase due to compaction under the HVS traffic
- Middle stable phase
- End phase in fatigue

CONSTRUCTION COST COMPARISONS



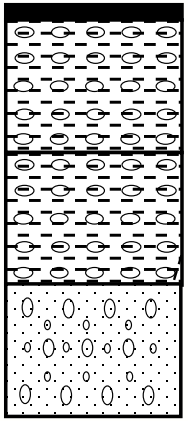
40 mm AC

150 mm G1/G2

150 mm C3/C4

150 mm selected

Conventional ES3 design



Bitumen-rubber double seal

150 mm silane-modified emulsion (1,5%)

150 mm silane-modified emulsion (1,0%)

Compacted subgrade

Alternative design

- 43% cheaper - R18 million saving on a 6.2 km road (D1884)
- 50% construction time saving for the project
- There is still a need for a life-cycle cost investigation

CONCLUDING REMARKS

- HVS testing at D1884 indicated exceptional performance of this section
- Nano-silane modification of marginal materials proven to be successful on this site
- This approach additionally yielded a 43% construction cost saving and a 50% construction time saving
- There is a need for more HVS testing – **current test K46 funded by GPDRT near William Nicol Drive in Johannesburg**

THANK YOU!

Acknowledgements to the Gauteng Province Department of Roads and Transport (GPDRT), Tshepega Engineering (Pty) Ltd and Kwagga Holdings (Pty) Ltd for HVS funding

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