Draft Protocols for MMLS3 Applications for Evaluating Rutting Deformation and Impact of Moisture under trafficking

Status Report to RPF08

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Pretoria

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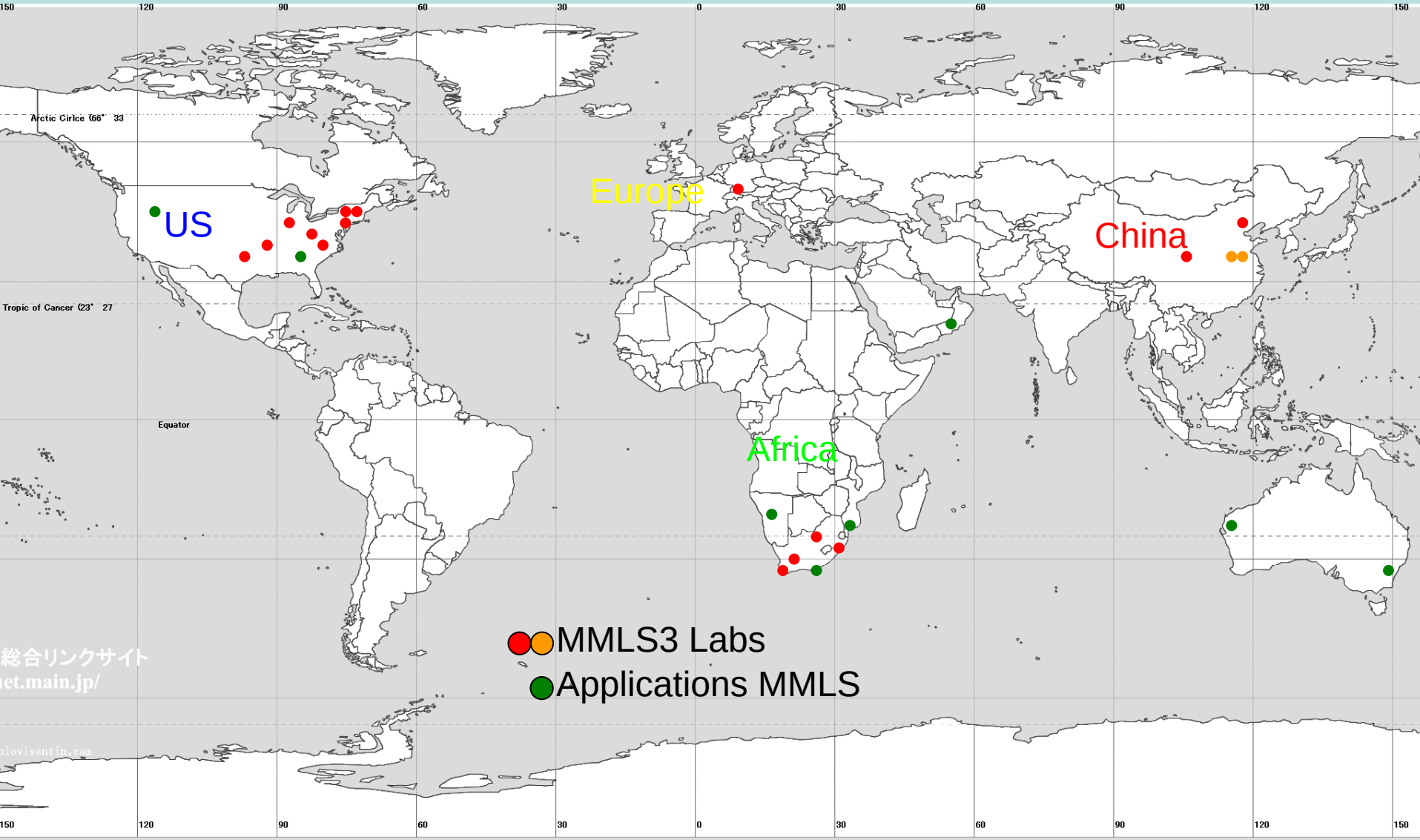
MMLS3 studies in global perspective



Historic brief - Westrack
Full-scale - MMLS3 comparison site

Westrack Full-scale - MMLS3 comparison site (close-up)

Westrack Field validation

QuickTime™ and a
decompressor
are needed to see this picture.

NCAT Test Track Alabama US

NCAT test track with 10m ESAL truck trafficking over two years

HVS and MMLS3 on R80 Pta West

QuickTime™ and a
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Close-up of MMLS3 set-up

QuickTime™ and a
decompressor
are needed to see this picture.

MMLS3 rutting vs HVS Rutting R80 Pretoria

Rutting due to Lateral Wander MMLS Trafficking on Rut Resistant Mix on R80

Namibia Field Application LTPP comparable to MMLS3 Performance Prediction

Field testing in Namibia

Rut after wet field testing

Instruction for Specimen Preparation and Trafficking						
Compaction Preparation						
Lab					Field	
H	G	R	R	R	R	R
Hammer	Gyratory	Roller	Roller		Roller	
Cylindrical mould		Slab	Slab		Slab	
Trafficking						
Channelized				Wander	Channelized	Wander

Instruction for Specimen Preparation and Trafficking (cont)

Test Conditioning				Temp C		Temp C
Moisture			Dry		Wet	
○ Surface	Inundate/Spray					
○ Internal*						
By inundating	Y	N				
* *By means of suction?*	Y	N				
Test Temperature						
Artificial Heating	Y	N				
○ Surface						
○ Minus 17mm	○ Minus 25 mm					
○ Minus 34mm	○ Minus 50mm					

Instruction for Specimen Preparation and Trafficking (cont)

Trafficking Wheel Load				kN	2.7		2.9
Tyre Pressure @ 25C				kN/m²	700	750	800
Tyre Tread (Std Diamond) Other				Diamond	Y		N
Assumed Contact Stress				kN/m²			
Axle Load Applications /h				Select	1800 2400 3600 7200		1800 2400 3600 7200
1800	***2400***	***3600***	***7200***				
Airport	***SteepGrd/ Intersections***	***Rolling grd & >>Truck***	***Highway Speed***				
Boundary Conditions							
▪ Compacted HMA+ Tack coat (Slab - Field/Lab)					Y		N
▪ Metal mould+emulsion interface (Test bed in Lab)					Y		N

Proposed Empirical Protocols for Acceptable Rutting Performance HMA >90mm							
	Lab					Field	
	Max Rutting under Trafficking to 100k axles (mm)						
	H	G	R	R	R	R	R
Hwy Speed	2.5	2.5	3	3	3.2	3	3.2
>>Truck	2.5	2.5	3	3	3.2	3	3.2
StpGrd/Intersect	2.1	2.1	2.5	2.5	2.7	2.5	2.7
Airport apron/Taxiway	1.8	1.8	1.8	1.8	2.0	1.8	2.0
Traffic Mode	C	C	C	C	W	C	W

Proposed Empirical Protocols for Acceptable Rutting Performance HMA >75mm							
	Lab					Field	
	Max Rutting under Trafficking to 100k axles (mm)						
	H	G	R	R	R	R	R
Hwy Speed	2.2	2.2	2.6	2.6	2.8	2.6	2.8
>>Truck	2.1	2.1	2.5	2.5	2.7	2.5	2.7
StpGrd/Intersect	1.9	1.9	2.3	2.3	2.5	2.3	2.5
Airport apron/Taxiway	1.5	1.5	1.8	1.8	2	1.8	2
Traffic Mode	C	C	C	C	W	C	W

Proposed Empirical Protocols for Acceptable Rutting Performance HMA 60 mm							
Lab						Field	
	Max Rutting under Trafficking to 100k axles (mm)						
	H	G	R	R	R	R	R
Hwy Speed	2	2	2.4	2.4	2.6	2.5	2.4
>>Truck	2	2	2.4	2.4	2.6	2.5	2.4
StpGrd/Inters	1.6	1.6	2	2	2.2	2	2.2
Traffic Mode	C	C	C	C	W	C	W

Proposed Empirical Protocols for Acceptable Rutting Performance HMA 40 mm							
	Lab					Field	
	Max Rutting under Trafficking to 100k axles (mm)						
	H	G	R	R	R	R	R
Hwy Speed	2.5	2.5	2.5	2.5	2.7	2.5	2.7
>>Truck	2.3	2.3	2.3	2.3	2.5	2.3	2.5
StpGrd/Inters	2	2	2.1	2.1	2.3	2.1	2.3
Traffic Mode	C	C	C	C	W	C	W

Points to understand regarding Protocols

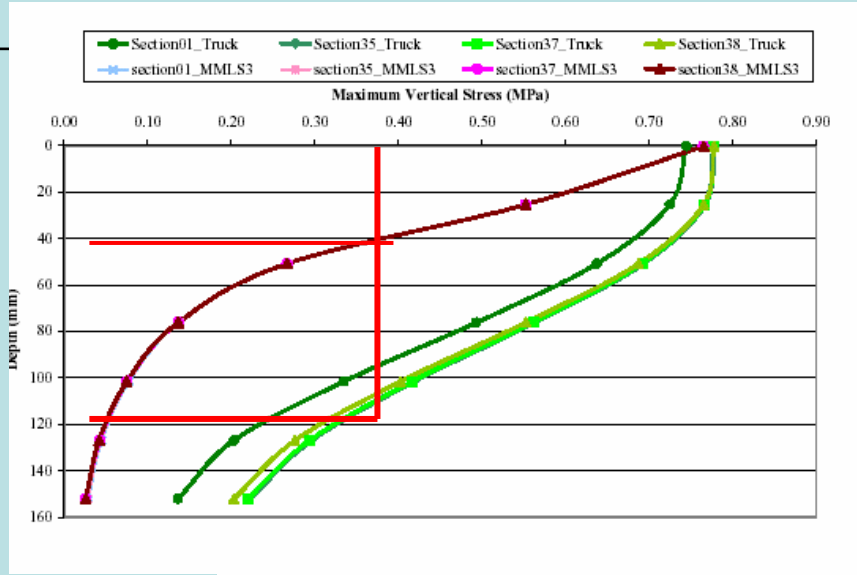
- Vertical stress, wander, temperature and frequency, have to be taken into account
- Westrack asphalt was 125 - 150 mm and the defined limits for rutting was related to10m E80s over 2 years.
  - South African applications have been adapted to local conditions relative to traffic and thickness
  - Evaluation of pavement performance under traffic with time after MMLS testing
- MMLS3 rutting performance comparable in *terms of ranking and extent*

Quantitative Analysis of Rutting

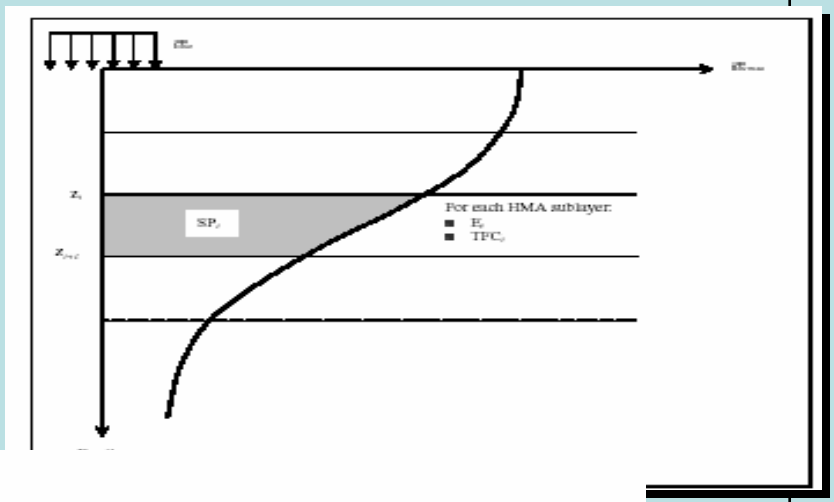
- Theoretical rut ratios (TRR) assumed proportional to vertical stresses in *pavement layers based on contact stresses*
- Corrections are made to account for differences in temp, age and load frequency *(speed)*
- Field rut ratios (FRR) are compared at similar trafficking axles with allowance for wander
- TRR / FRR = 1

Analysis of MMLS3 Performance

Stress under MMLS3 and Large wheels



Temperature distribution



$$SP_i = \int_{z_i}^{z_{i+1}} \sigma_{v\,max}\, dz$$

Stress Potential

where

$\sigma_{vc\,max}$	=	maximum vertical contact stress on the pavement beneath the tire
z	=	depth in the pavement structure
i	=	sublayer number

Rutting Performance Ratios and Field Rutting Ratios

RPR = Rutting Potential Ratios

FRR = Field Rutting Ratio

$$RPR = \frac{\sum_{i=0}^{n} TFC_i \times SP_i^{MMLS3}}{\sum_{i=0}^{n} SP_i^{Trucks}}$$

where

n = number of HMA sublayers

$$FRR = \frac{\left(RD_{100k}^{MMLS3}\right)_{HMA\ layer}}{\left(RD_{100k}^{Trucks}\right)_{HMA\ layer}}$$

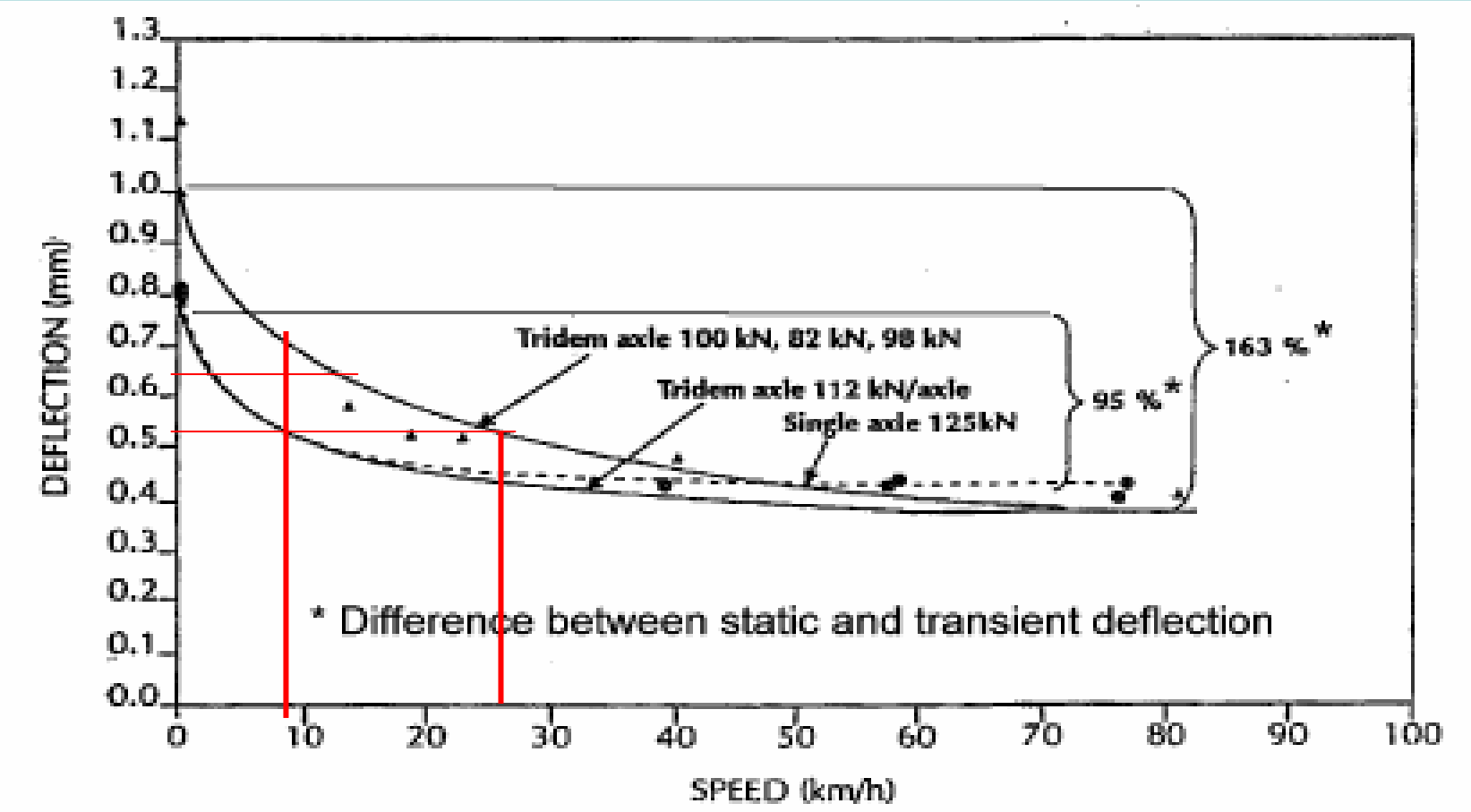
$$= \frac{\left(RD_{Top\ of\ HMA\ layer} - RD_{Bottom\ of\ HMA\ layer}\right)_{100k}^{MMLS3}}{\left(RD_{Top\ of\ HMA\ layer} - RD_{Bottom\ of\ HMA\ layer}\right)_{100k}^{Trucks}}$$

Thus Comparative Performance:

- Similar Distress characteristics

- Related rutting performance with consideration of
  - *Scaled and Full-scale stress* and strain at similar
  - *temperature, age and load frequency*

Deflection vs. speed under full-scale truck traffic

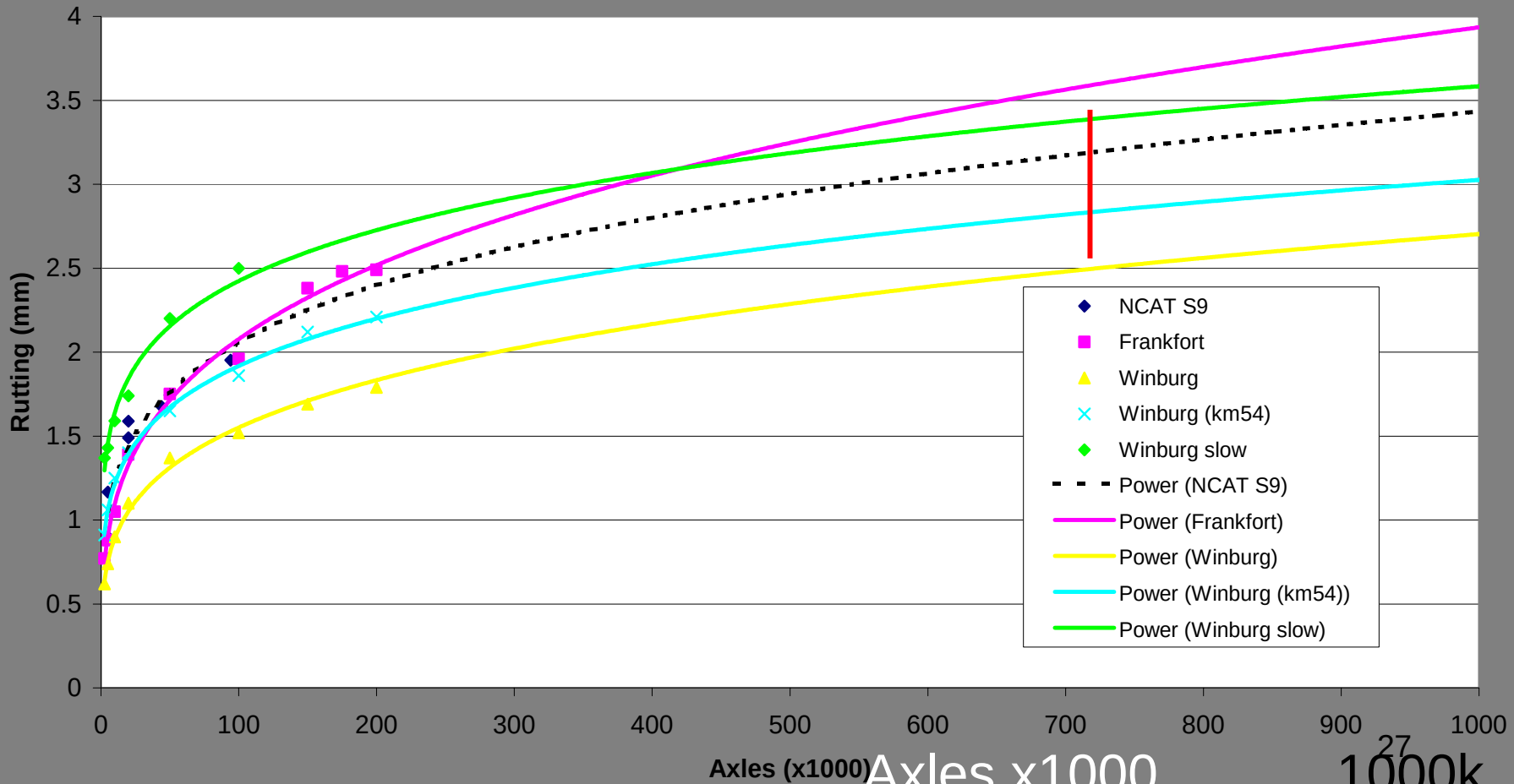


Comparitive MMLS3 rutting @ different trafficking speeds in Winburg SA and NCAT

Rutting mm

4mm @ 1000k

Fig. 9: Comparative summary of results

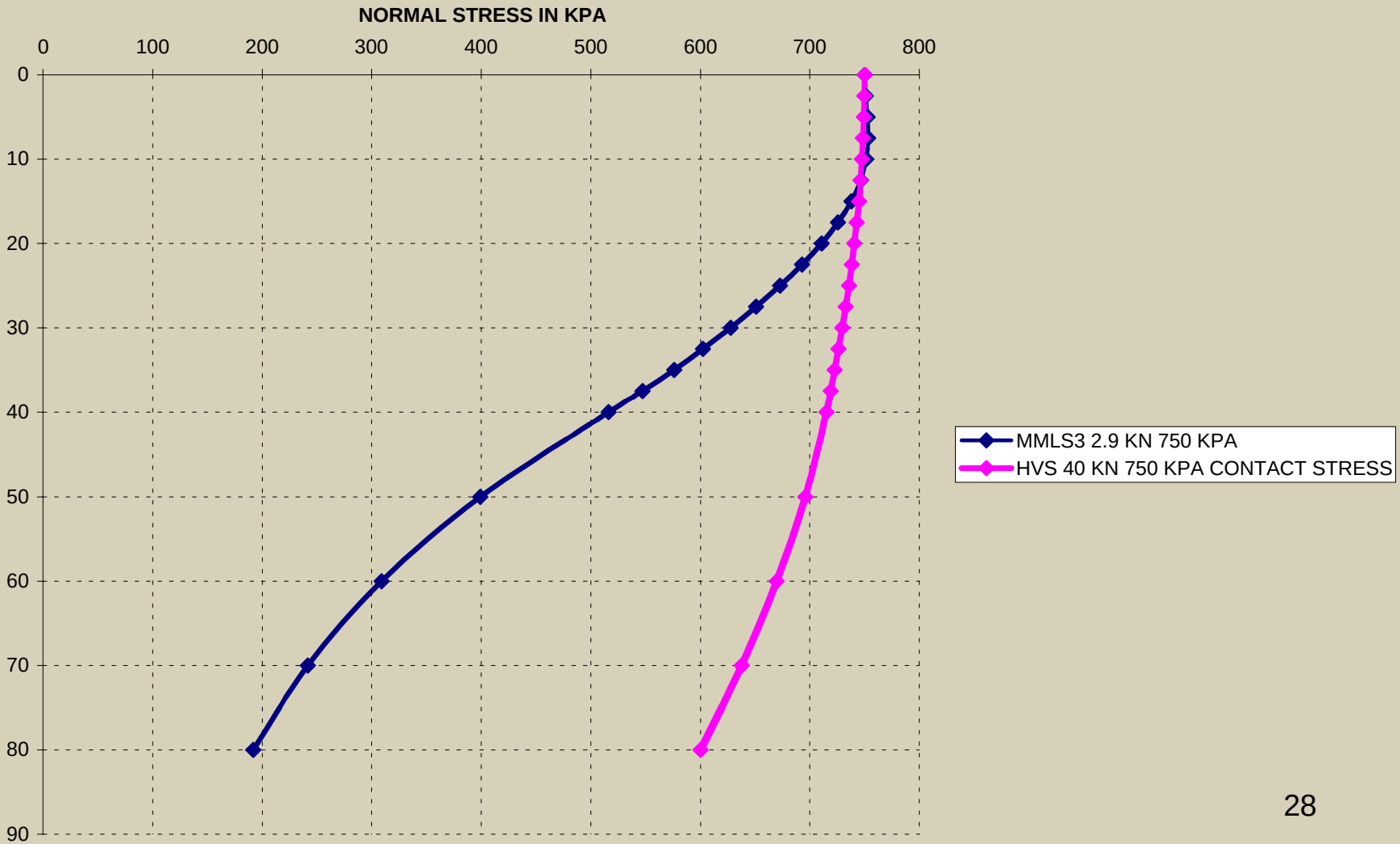


Axles x1000

1000k

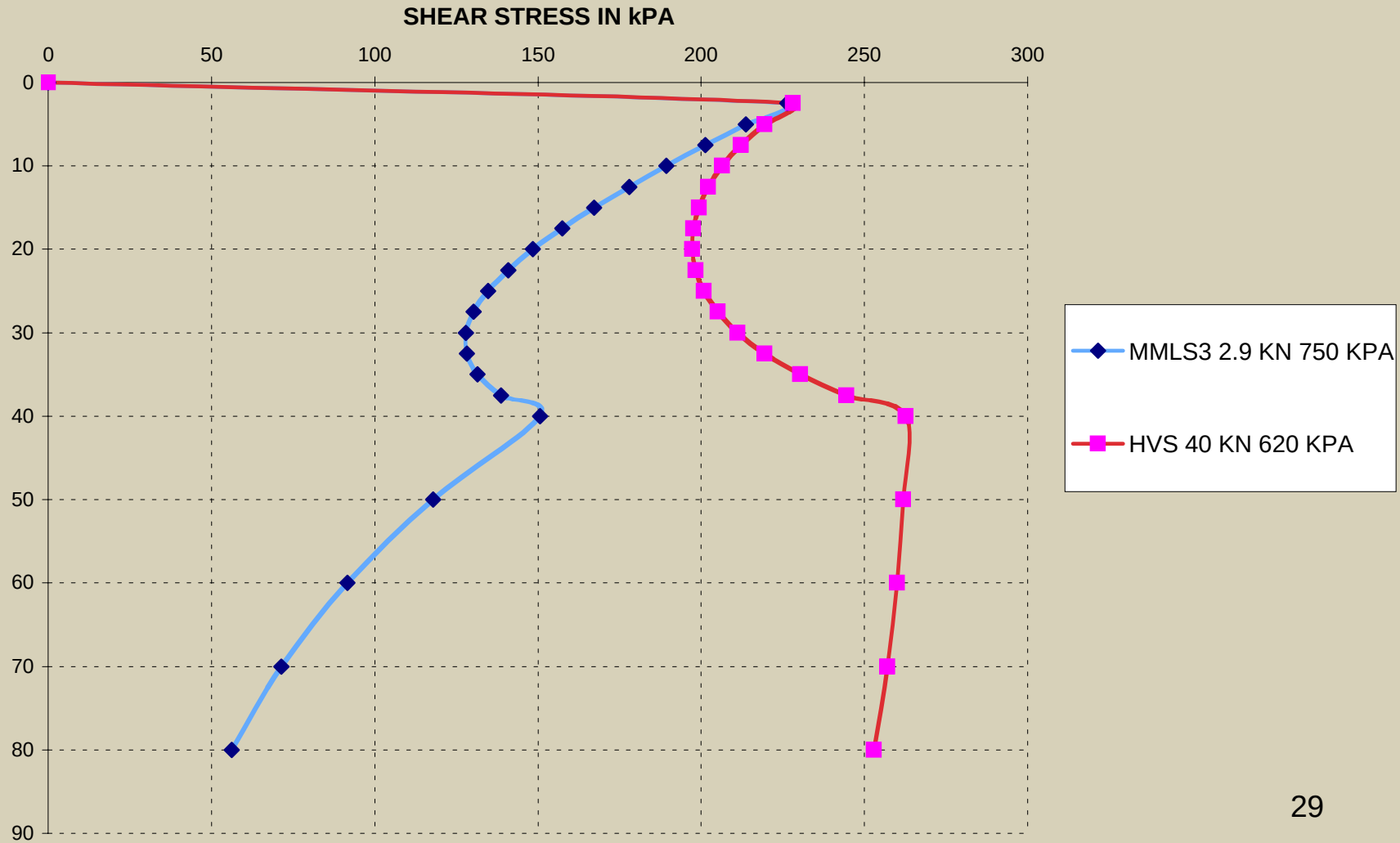
VERTICAL CONTACT STRESS PROFILES

MMLS3 vs.HVS @ 750 kPa contact stress– 91% (R80 Pta West)

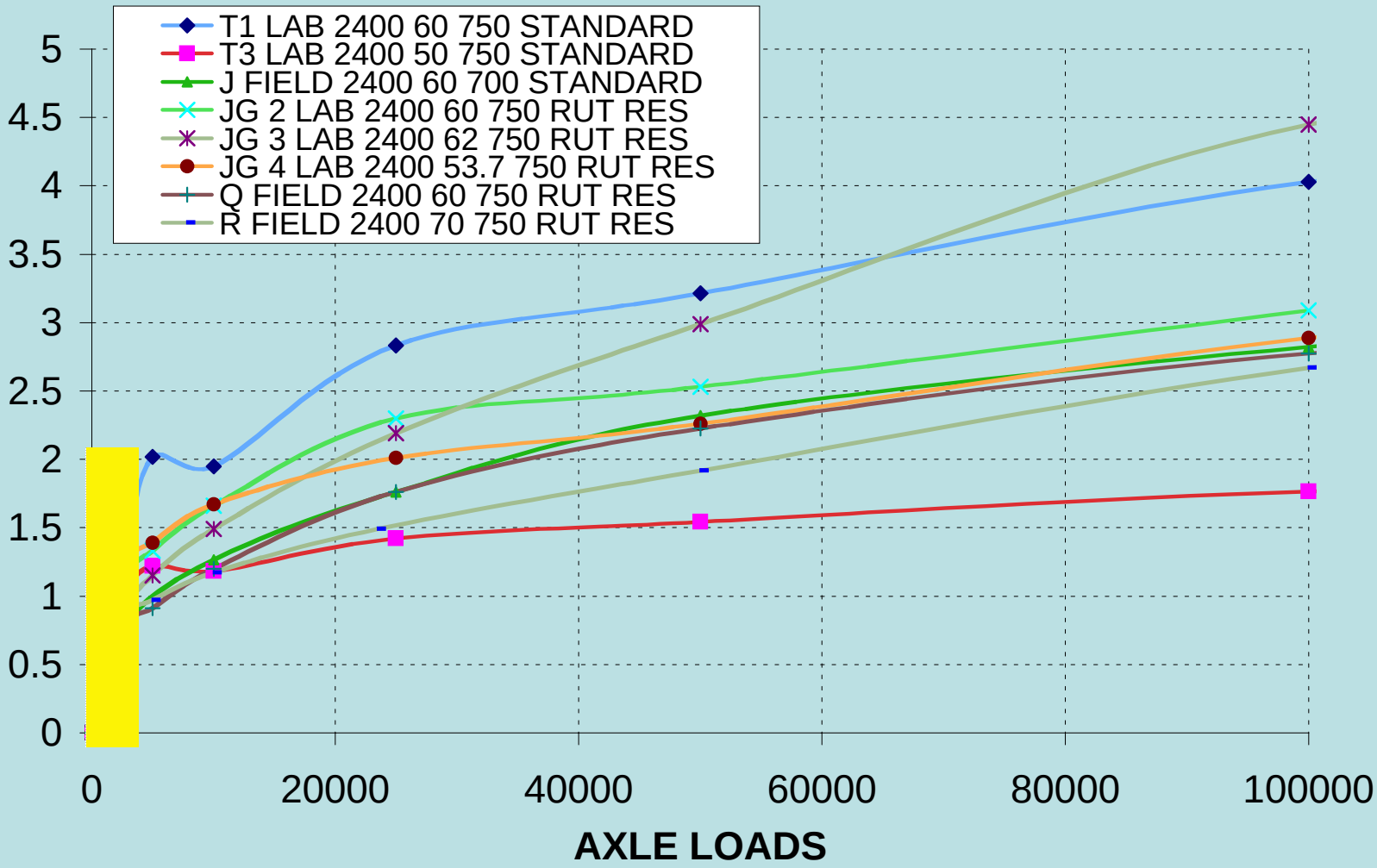


SHEAR STRESS PROFILES

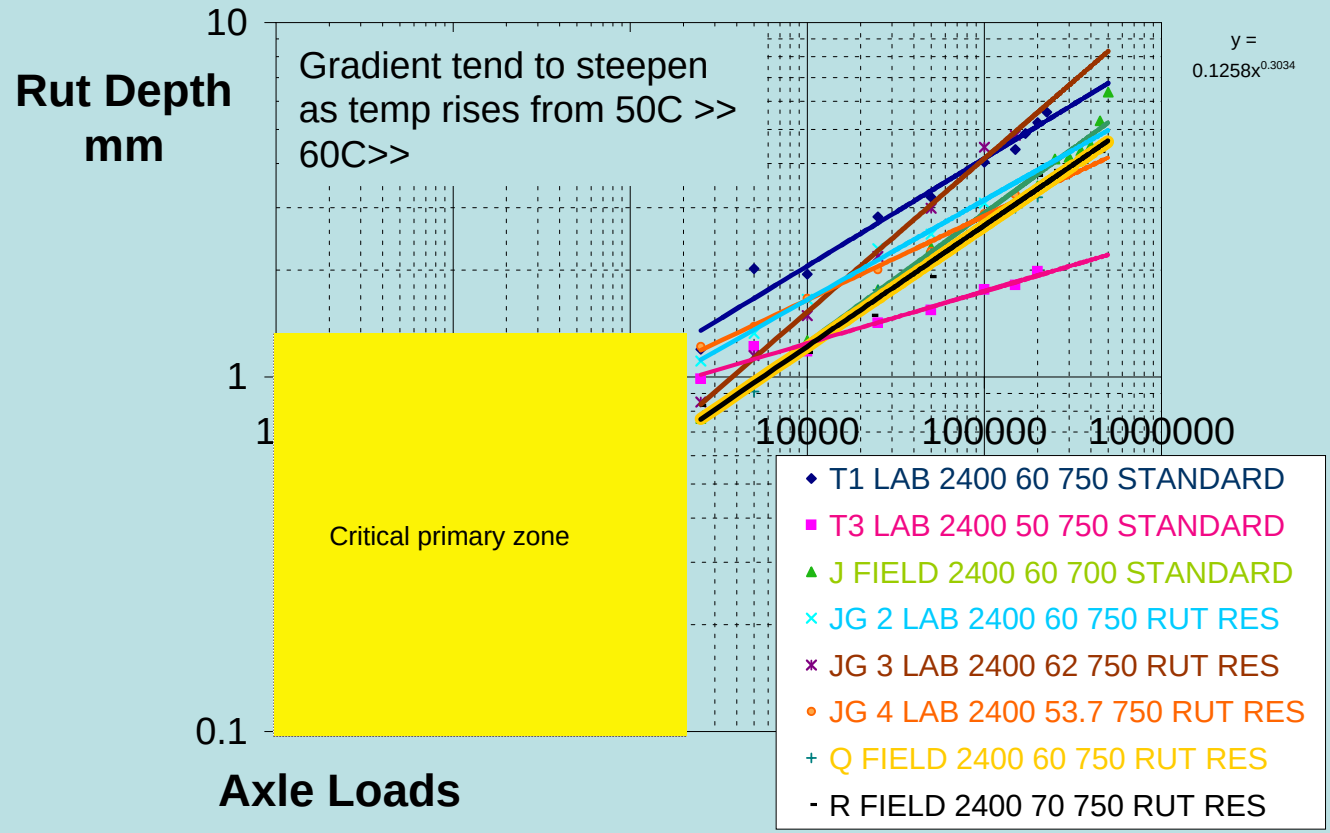
MMLS3 vs. HVS @ 750 kPa contact stress–75% (R80 Pta West)



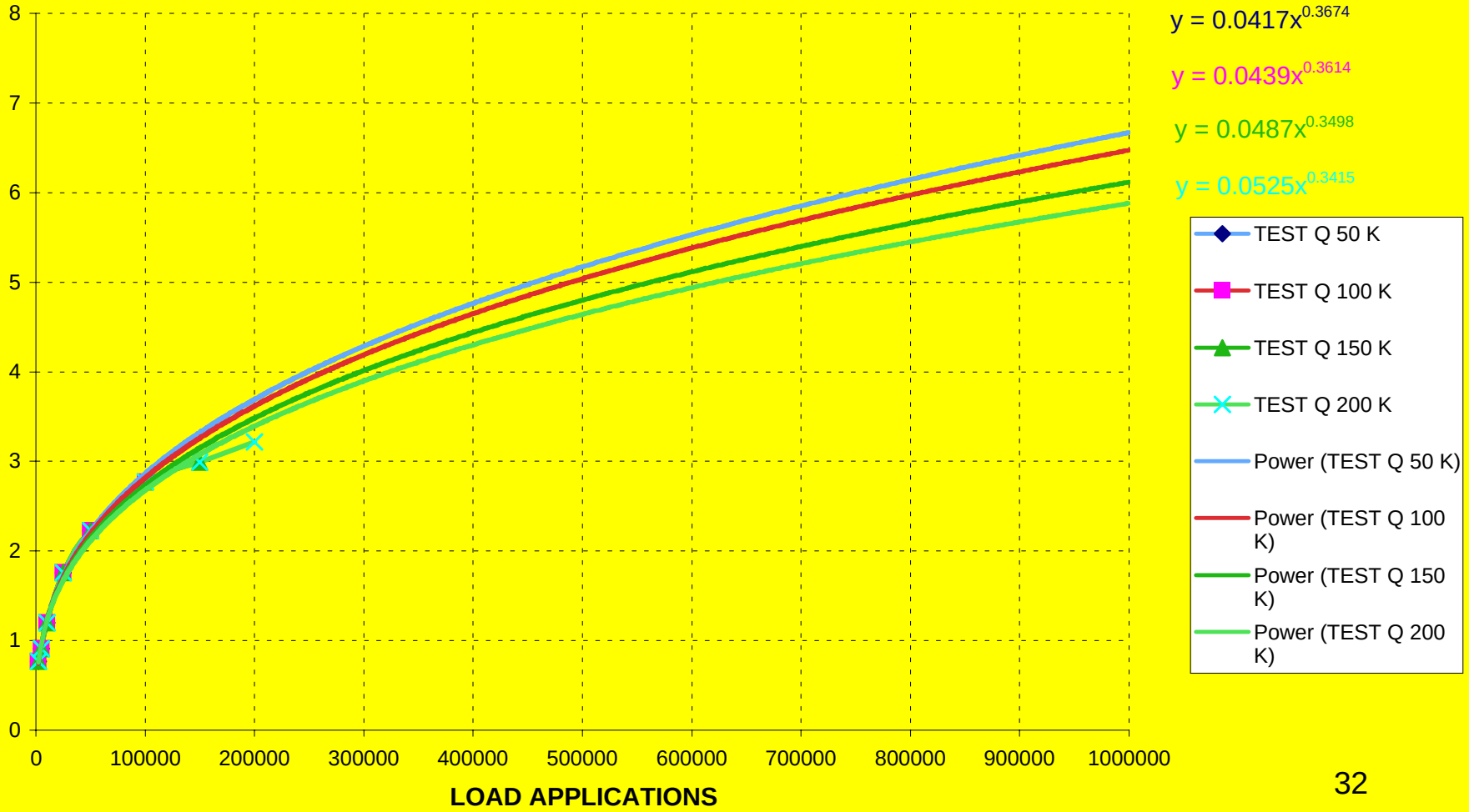
MLS Comparative Rutting Performance of Standard and Resistant Mixes in the Laboratory and Field



MMLS Comparative Studies of Standard and Rut Resistant Mixes in the Laboratory and Field



MMLS3 Data Processing (R80 Pta West)
Extrapolation of Rutting Data:
0-50k; 0-100k; 0-150k; 0-200k = 12% difference



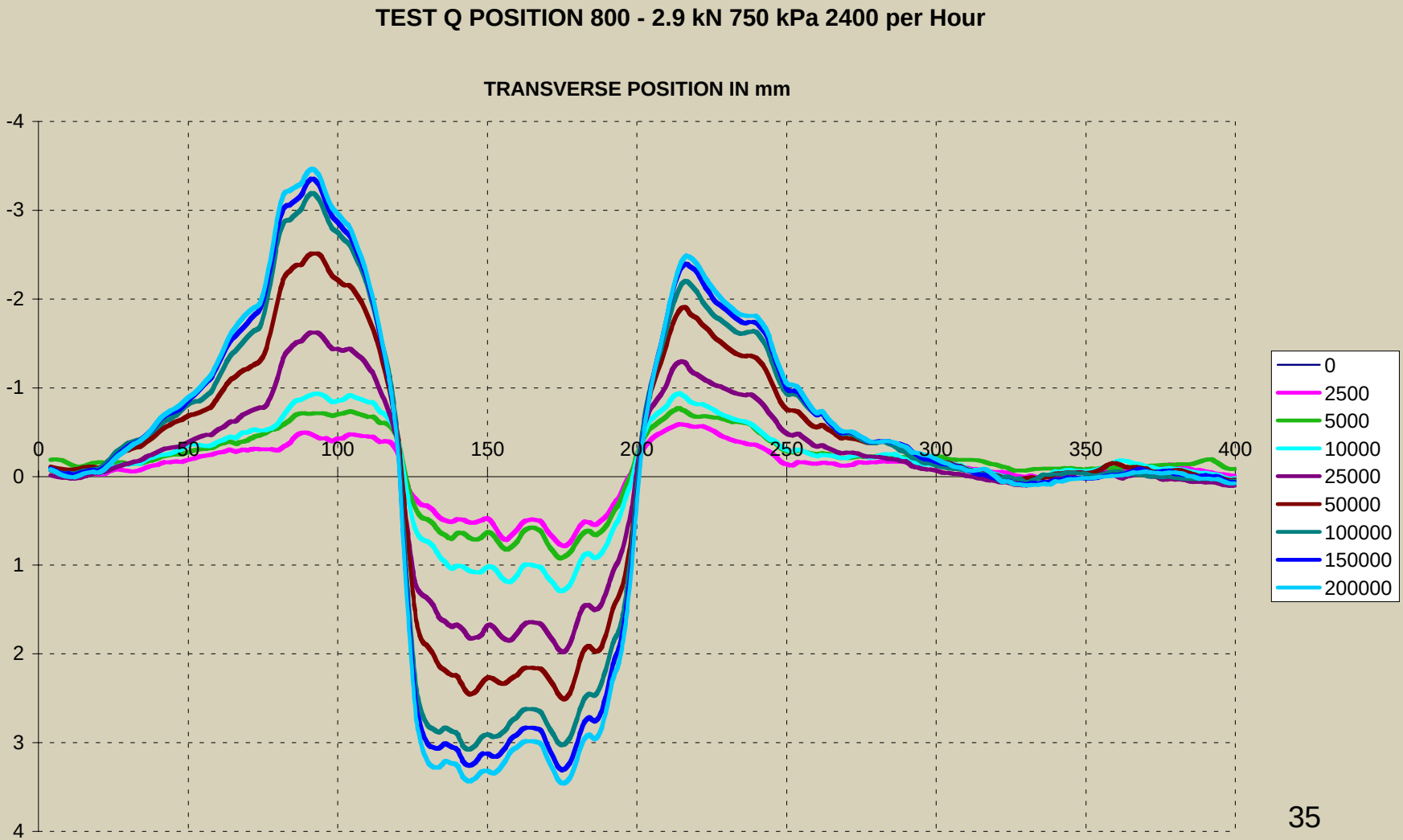
Recent Conclusions from MMLS3 APT Study in So Africa

1. Field and lab MMLS have comparable Rutting Performance if conditions are similar in terms of temperature, contact stress and load frequency
2. Rutting in terms of downward deformation and upward heave under MMLS trafficking is similar in field and lab
3. Effect of Lateral Wander trafficking appears to be severe in thin asphalt layers

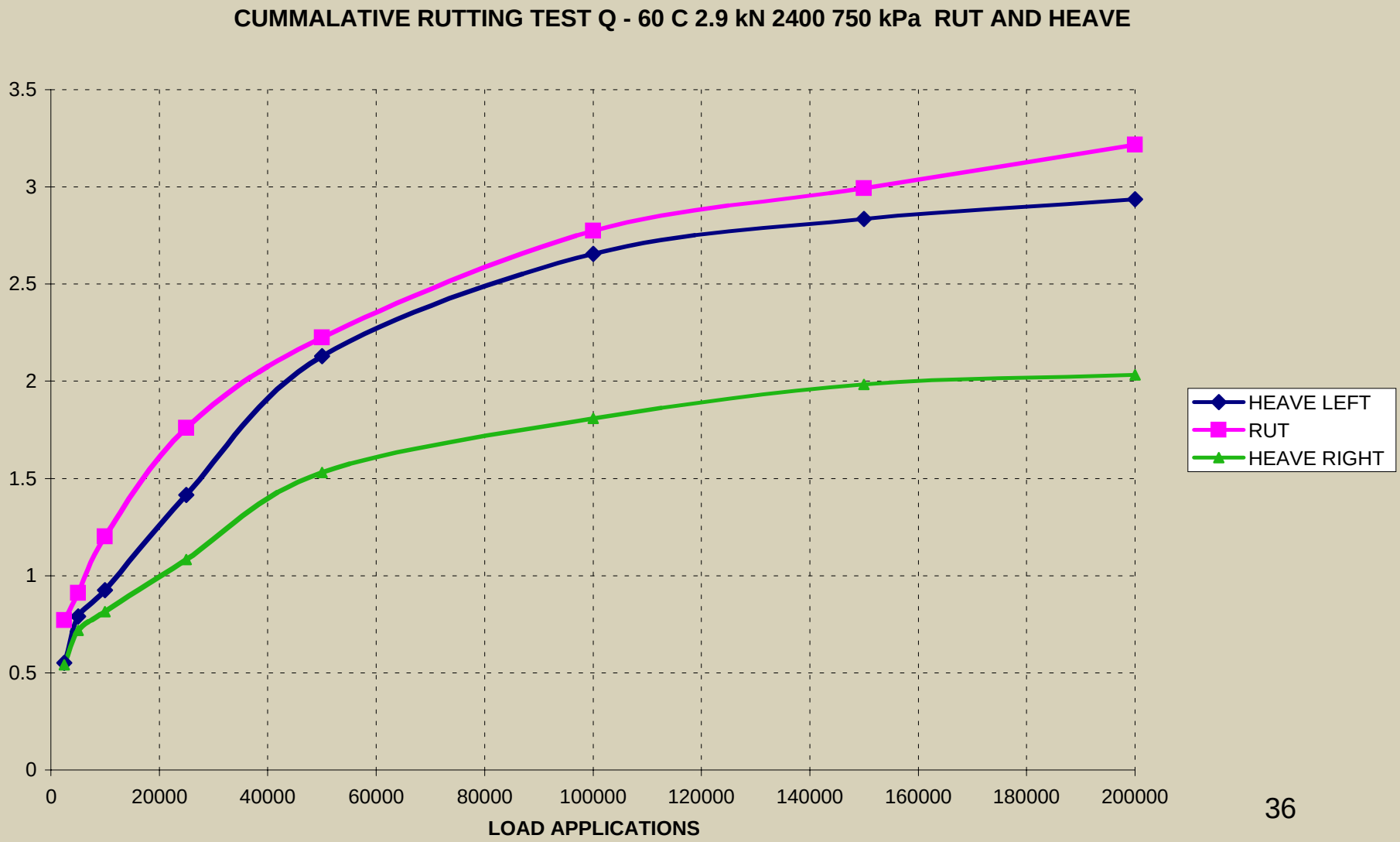
Points to understand regarding Protocols

1. Environmental impact
   - Temperature
   - Rainfall
   - Aging - geographic location
2. Traffic volume
3. Traffic speed
   - Gradient
   - Elevation
4. Wheel load and tyre pressure
5. Pavement structure, materials and construction

MMLS3 Data Processing (R80 Pta West)
Rutting Profiles - Heave (left and right@ 800mm)



MMLS3 Data Processing (R80 Pta West)
Rutting vs. Heave (left and right)



Lab Testbed

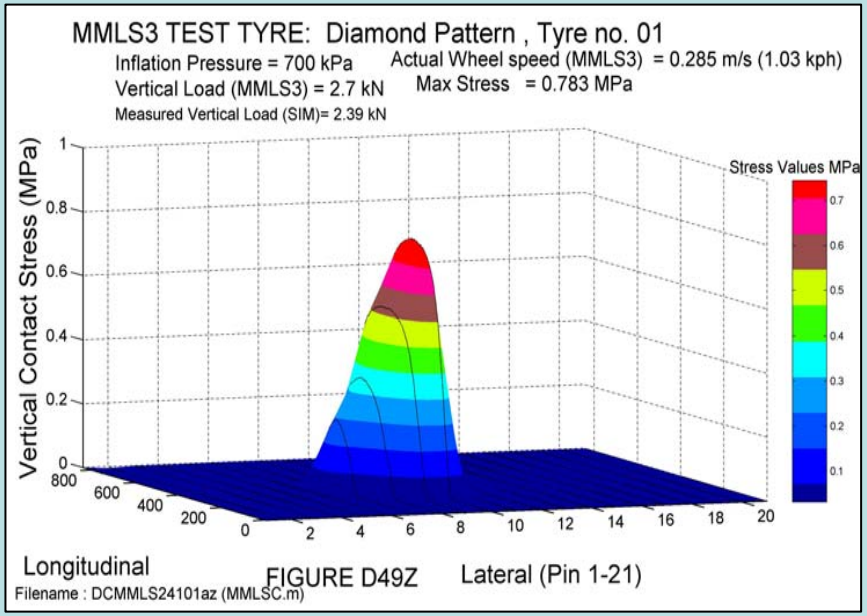


FIGURE D49Z

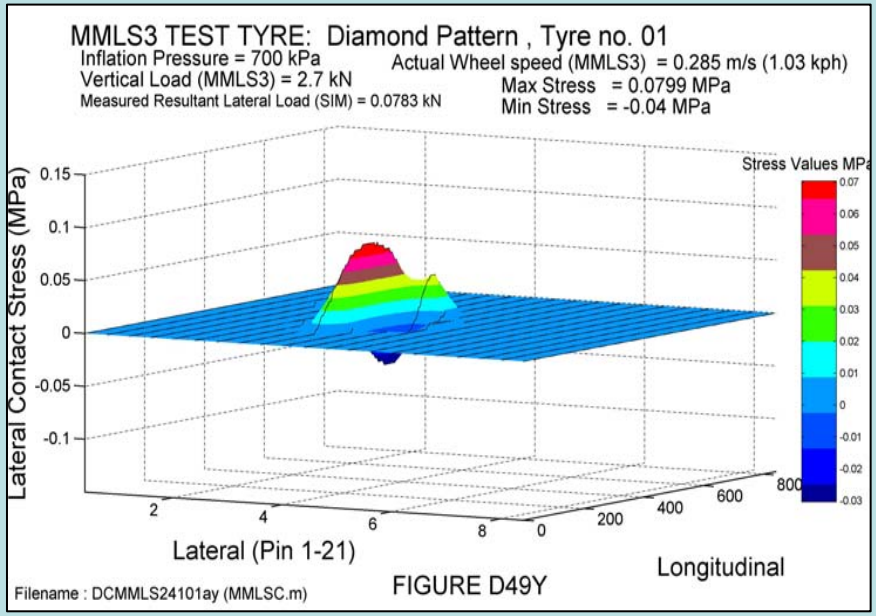


FIGURE D49Y

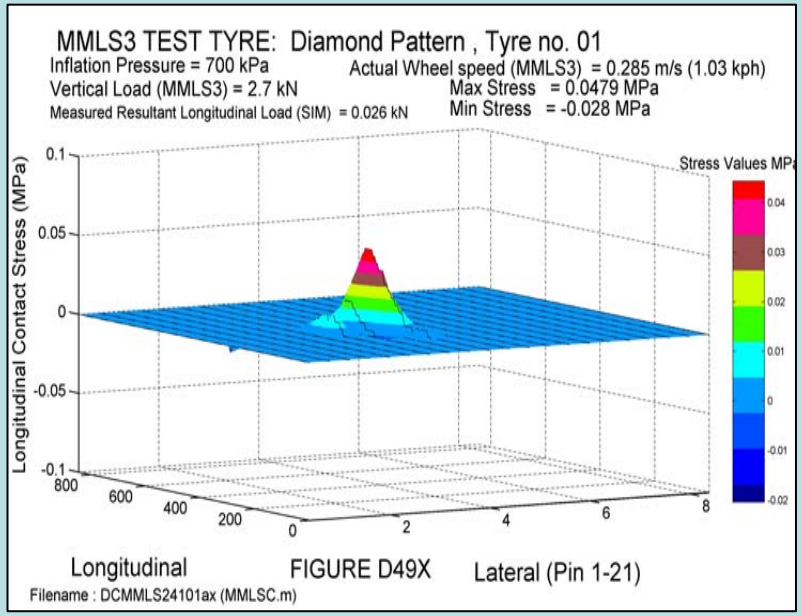
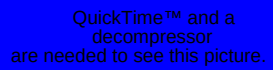
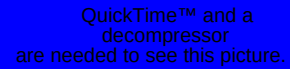


FIGURE D49X

Cores after MMLS3 testing





Key to application of the MMLS3

Understanding APT:

- distress mechanisms
- performance related factors

Salient Features of MMLS3 Testing that need to be borne in mind

Pins for measuring deformation below layer #1

Applications by MMLS3 Users

Output/Variables/ Data interpretation protocols

Variables

- Wander
- Loading
- Speed
- Contact stress
- Conditioning
  - Heat
  - Ambient
  - Cooled
  - Wet/Dry
  - Ageing

Westrack Field validation

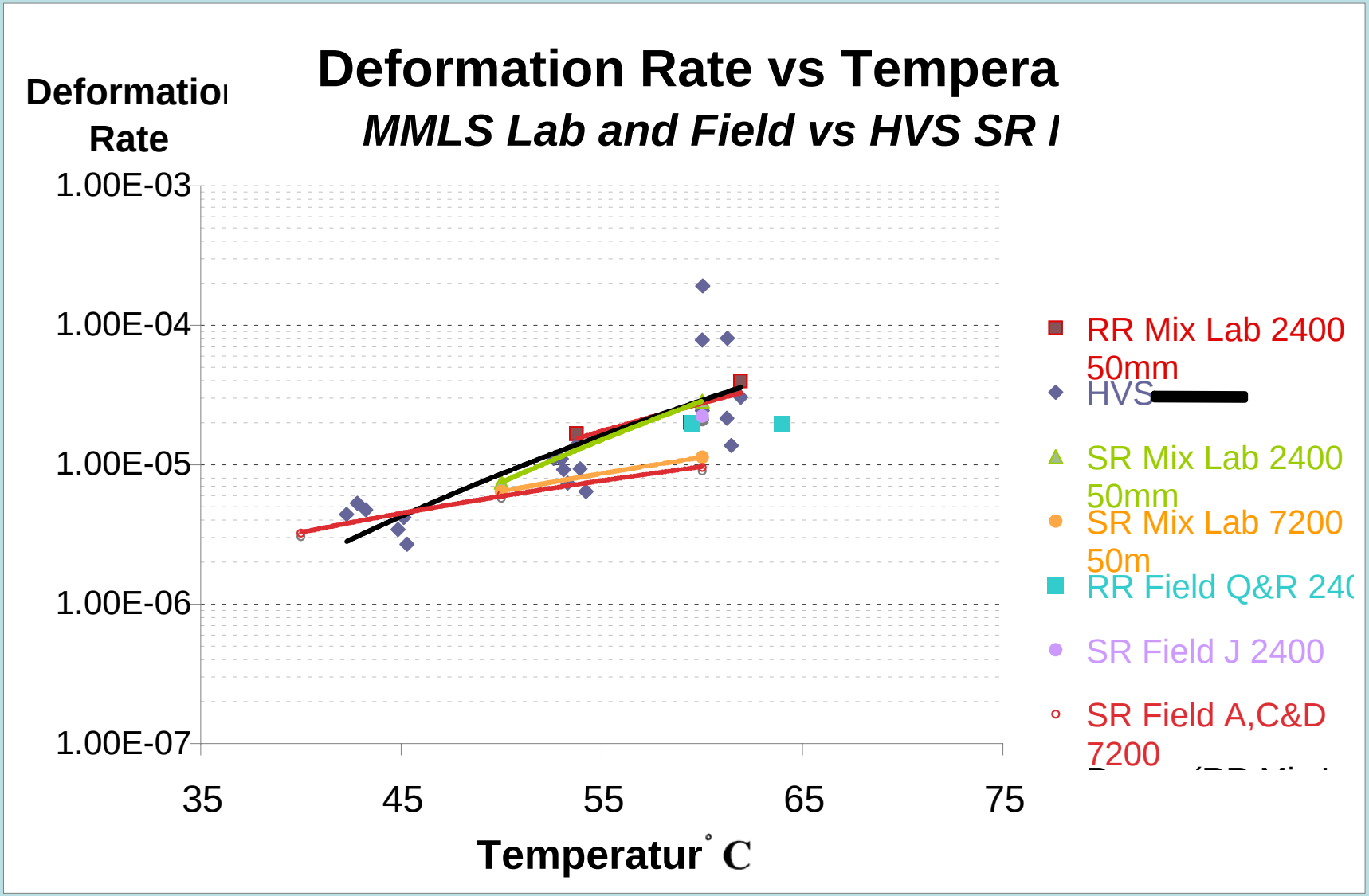
QuickTime™ and a
decompressor
are needed to see this picture.

MMLS3 with heating ducts

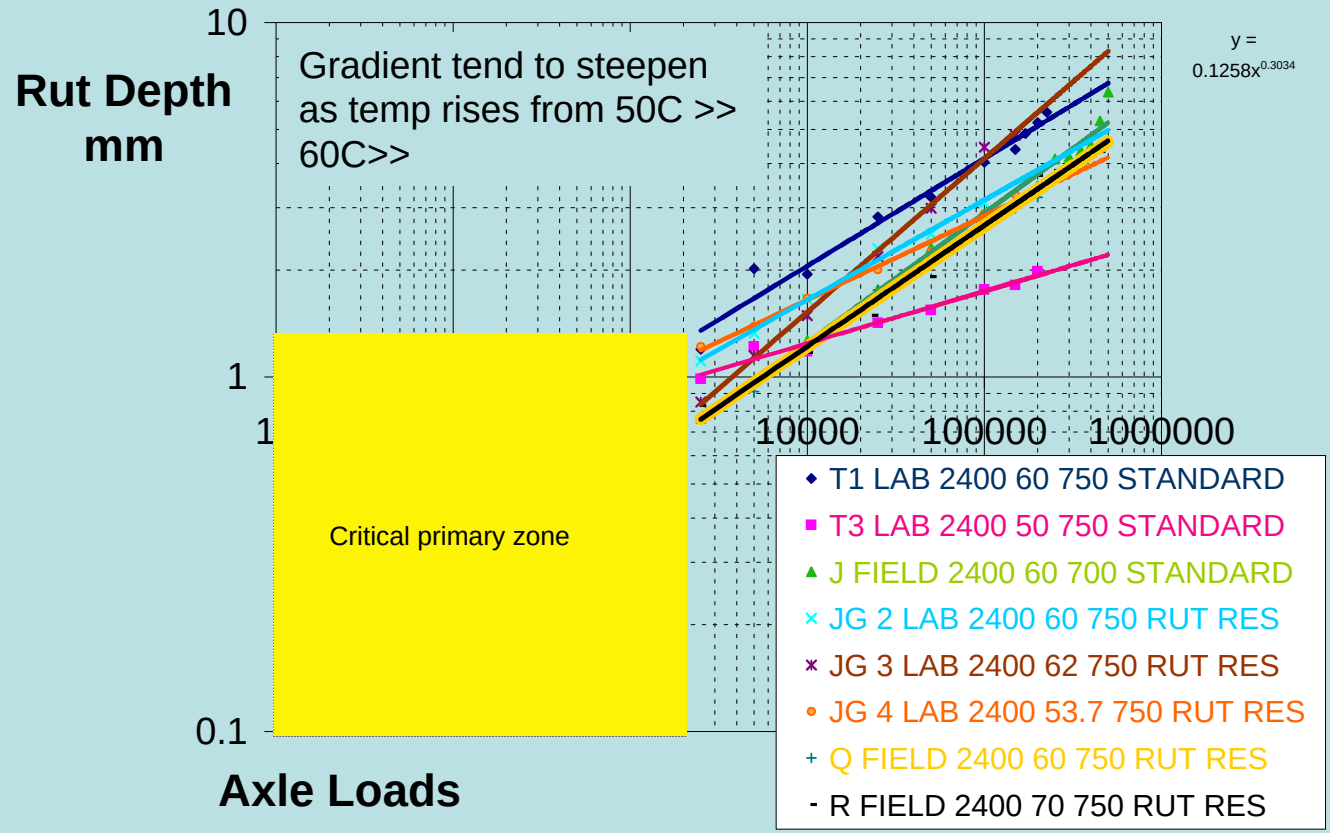
QuickTime™ and a
decompressor
are needed to see this picture.

Combined Heating and Cooling Unit (-10C to 70C)

Comparative Performance of *Standard and Rut Resistant* Mixes Under MMLS Trafficking vs. HVS Trafficking of Standard Mixes



MMLS Comparative Studies of Standard and Rut Resistant Mixes in the Laboratory and Field



Rutting and Shear Deformation due to Lateral Wander MMLS Trafficking on Rut Resistant Mix

Comparative Performance of *Standard and Rut Resistant* Mixes Under MMLS Trafficking vs. HVS Trafficking of Standard Mixes