Verification of Traffic Speed Deflectometer measurements using Instrumented Pavements in South Africa

L Kannemeyer / W Lategan / A Mckellar
South Africa has the 10th Longest Total and 18th Longest Paved Road Network in the World

Roads Represents one of the largest public infrastructure investments in most countries

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<th>Rank</th>
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South African Pavement Design

Increased Number of Heavy Axles Repetitions over 20-30 year Design Life

Due to Budget Constraints, South African Pavement Design (30-40% Cheaper) is not zero maintenance design

Waterproof Layer

South Africa

Northern Hemisphere

Local Street

Farm To Market

Typical National

Interstate Road

(10 to 40 mm)

Water Path Length

(100 to 400 mm)
**Asset Management System**

**Building Blocks/ Puzzle Pieces of AMS**

- **Policy/Procedures** – Principles/Rules to Guide Decisions and achieve rational outcomes – what, where, when, how.
- **Funding** – Financial resources for operation and results implementation.
- **People** - People make decisions, the rest are just to support the process.
- **Hardware** – Road Survey Equipment + IT Infrastructure.
- **Software** – Computer based data Analysis and Storage Tools.
- **Data** – Knowing what you have, its condition and performance Trend.
For asset management to be successful all the “pieces of the puzzle” need to be in place in a “balanced equilibrium”

It does not help you have the most advance survey vehicle but no means to effectively store and analyse the data, or

Have the most sophisticate software, but the quality of your data is suspect!

Without Funding and People – Nothing will happen!!!
SANRAL TSD 10 Doppler Lasers

Continuous Dynamic Load/Tire Pressure and Temperature / IRI / Macro Texture
Survey equipment such as the Trimble MX8 and Waylink PaveVision3D Ultra systems, are stored inside the trailer and can be ready for surveys within seconds with the push of a button.

When the vehicle is not surveying, the equipment are stored again inside for safekeeping and cleaning.
Trimble MX8 Mobile LiDAR Solution

2 x REIGL Laser Scanners, 7 x 5MP Cameras, Applanix 520, Trimble DGPS

AUTOMATED EXTRACTION:
- Pole Detection
- Sign Detection / Recognition
- Pavement Marking Detection
- Road Modeller (DTM, Cross Sections, Profiles)
- Horizontal / Vertical Line of Sight
- Horizontal / Vertical Clearances

3D Laser Point Cloud
Waylink PaveVision3D Ultra

8 x 3D Range (Height) & Intensity Line Scan Cameras, Green Laser Light Source

Using 3D Vision system we can currently automatically detect and measure:

- Surface racks with a width of as little as 1.00mm;
- Rutting across lane width from continues line;
- Macro Texture across lane width;
- Faulting on Concrete Pavements and 3D Virtual Pavement
High Repeatability of results that are independent in terms of:

- **Speed** – 20 km/h to 80 km/h
- **Roughness** – IRI 0.8 to 6.0 m/km
- **Deflection** – D0 0.1 to 1.5 mm
- **Macro Texture** – MPD 0.7 to 3.0 mm

![Graph showing speed vs. Doppler position](image1)

![Graph showing roughness vs. travelled distance](image2)

![Graph showing deflection vs. travelled distance](image3)

![Graph showing macro texture vs. travelled distance](image4)
SANRAL TSD Dynamic Loading

95th Percentile Increase by ±20%

SAT Site 4 - IRI 4.5-6.0 (m/km)

Axle Group Load (kg)

Distance (m)

Load Left [kg] (20 km/h)  Load Right [kg] (20 km/h)  Load Left [kg] (80 km/h)  Load Right [kg] (80 km/h)
SANRAL TSD vs FWD

Same Pattern - but shift in sensor position when compared to FWD
SANRAL TSD vs FWD

- Although FWD has been around for some time, cannot be used as the true reference for accepting TSD measurements:
  - FWD Maximum Deflection versus Time History
  - FWD Rubber Buffer Temperature Sensitivity (Pulse Duration)

- R104 Instrumented Sections
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- **150 JCP**
- **150 JCP**
- **150 C3 TBC (Donkerhoek/Quicksand)**
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- **150 C3 TBC (Donkerhoek/Quicksand)**
- **150 C3 TBC (Donkerhoek/Quicksand)**
- **280 G7 (Ex-pavement Layers)**
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- **280 G7 (Ex-pavement Layers)**
- **270 G7 (Ex-pavement Layers)**
- **250 G7 (Ex-pavement Layers)**

- **200 G7 (Ex-pavement Layers)**
- **70 UTCRCP**
- **70 UTCRCP**
- **70 UTCRCP**
- **70 UTCRCP**
- **55+ 25 CBP**
- **55+ 25 CBP**
- **55+ 25 CBP**
- **55+ 25 CBP**
- **55+ 45 CBP**
- **55+ 45 CBP**
- **55+ 45 CBP**
To Correctly Interpret TSD Data - Need To understand pavement response
R104 Instrumented Sections - Construction

Instrumentation Installed as part of layer construction

Strain Gauges and Pressure Cells

Pressure Film

Typical Layout top of asphalt base
Multi Depth Deflectometer (MDD)
R104 Instruments – Pressure Film

- Pressure Measurement Sensors (0.2 mm)

Trail inner tyre – 31.2, 34.8, 38.3, 42

| 39 742 mm² | 42 219 mm² | 54 606 mm² | 56 981 mm² |

Trail outer tyre – 31.2, 34.8, 38.3, 42

| 33 445 mm² | 36 955 mm² | 47 897 mm² | 50 890 mm² |
Synchronising TSD/R104 measurements

At 80km/h moving at 22.22 m/s
MDD Deflection Location

D0 MDD Surface Deflection

Offset (mm)

-300 -200 -100 0 100 200 300 400 500 600

-900 -800 -700 -600 -500 -400 -300 -200 0

100mm Sensor Value?

150mm Granular Base
150 mm Asphalt Base
Surface Velocity (60 km/h)

- TSD Velocity - Before Remote Focus
- MDD Velocity

MPD > 2.5 only 4 degrees
D0 Surface Deflection (60 km/ h)
D0 Deflection versus Speed

- Below 30 km/h Exponential (Visco Elastic)
- 30 to 80 km/h Straight Line (Elastic)

TSD measures “real” pavement response, even at low (<30 km/h) speeds
SANRAL TSD Conclusions

- TSD measurements highly repeatable.
- TSD and FWD has same pattern but not exact match for valid reasons.
- The 100mm sensor location on very flexible pavements?
- TSD Doppler Laser range focus is crucial!
- Deflection at reference sensor 3.5m is not zero, although slope is close to zero- relocate to 3.0m?
- TSD Statistical Deflection model huge improvement over old beam model, but not 100% - Muller/Roberts PCHIP curve fit.
- TSD measures real pavement behaviour even at speeds as low as 2.5 km/h.
- TSD is not just network deflection scanning tool.
Thank you!

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