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Investigation of Pavement Responses Using Multi-Depth Deflectometer

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Introduction

Problem Statement

- Rutting is one of major distresses in flexible pavement.
- It leads to the structural failure of the pavement.
- It causes hydroplaning and its poses safety problem in night times as shown in figure below.

Figure 1: Field rutting in a flexible pavement

Objective

To study layer-wise rutting of a flexible pavement using a multi-depth deflectometer and compare the strain developed in subgrade with a linear elastic software.

Methodology

- Construction of test track
- Application of load with Heavy Vehicle Simulator (HVS)
- Development of relation between number of passes and rutting for each layer.
- Measuring surface profile for total rut
- Collecting deflection using data acquisition system
- Comparing the strain developed using software and field conditions

Test Sites: CSIR-CRRI

The pavement was designed for 30 Million Standard Axle (MSA) traffic and 5 % CBR.

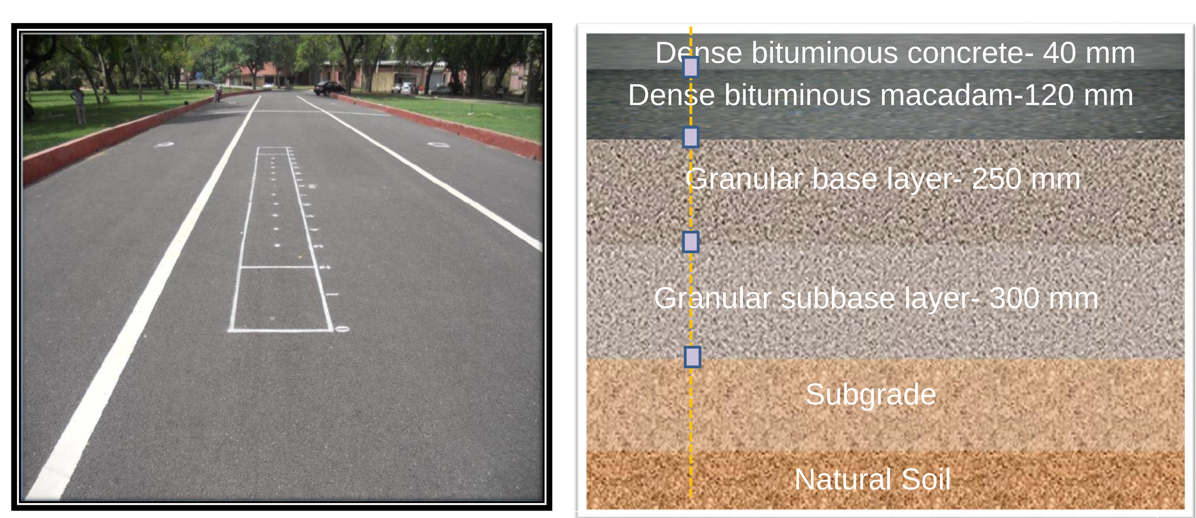
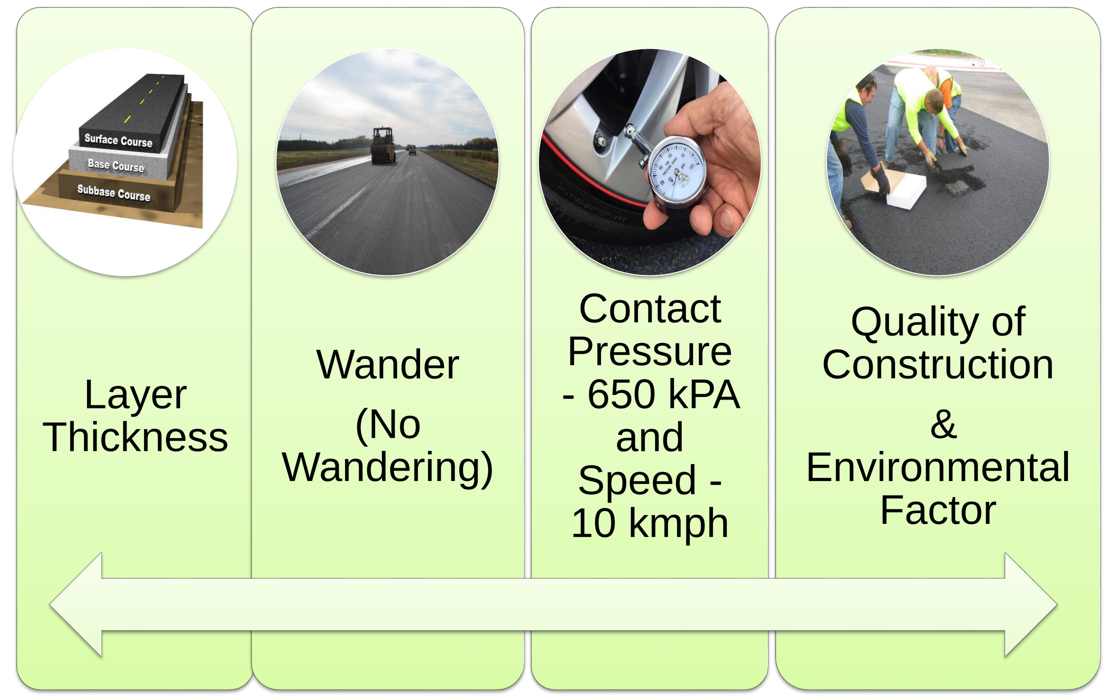


Figure 2: Crust composition of pavement

Field Tests

Factors Affecting Rutting



- The design and construction of the test section has been done as per ministry specifications.

Table 1: Bituminous mix property

Binder type in mix	Optimum binder content (%)	Bulk density (g/cc)	Marshall stability (kN)	Retained marshall stability %	Flow (mm)	Air voids (%)	VFB (%)
DBC	5.1	2.280	10.22	83	3.1	4.2	71.7
DBM	5.0	2.301	10.15	79	3.5	4.9	69.3

Instruments Used

Multi-Depth Deflectometer

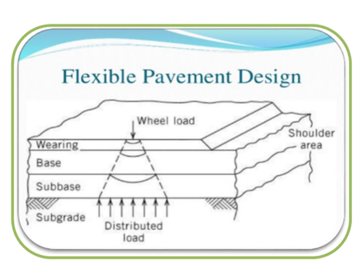
Laser Profilometer

HVS Mark IV+

Falling Weight Deflectometer

Data Acquisition System

Benkelman Beam Deflectometer



Linear Elastic Software

Weather Station

Data Analysis

Heavy Vehicle Simulator (HVS)

- The deflections were measured using a Multi-Depth Deflectometer (MDD) at the interface of each layer.
- The deflection observed using MDD under loading at 40 mm is the sum of the deflection of all layers.

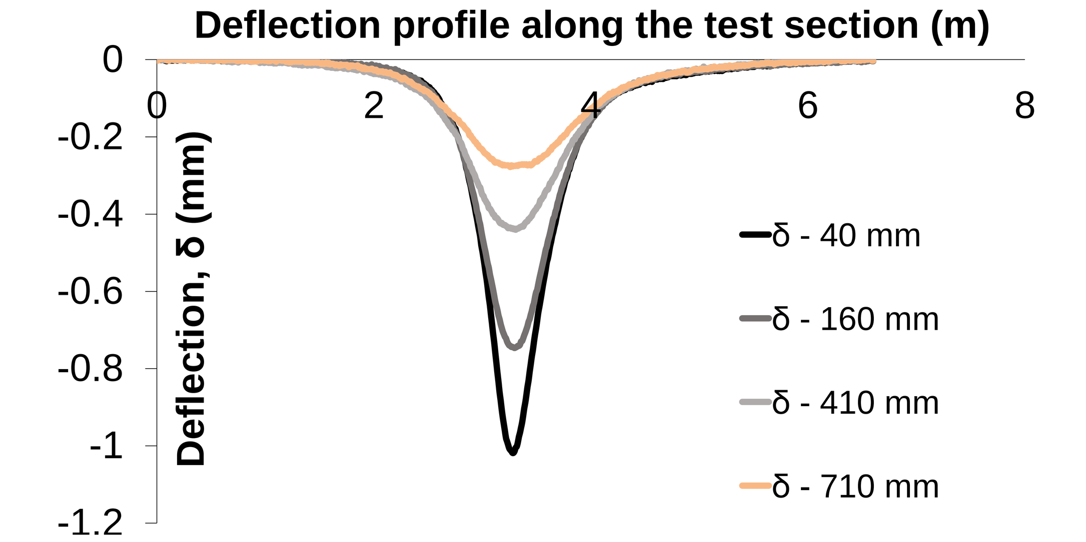


Figure 3: Typical deflection at the interface of pavement layer

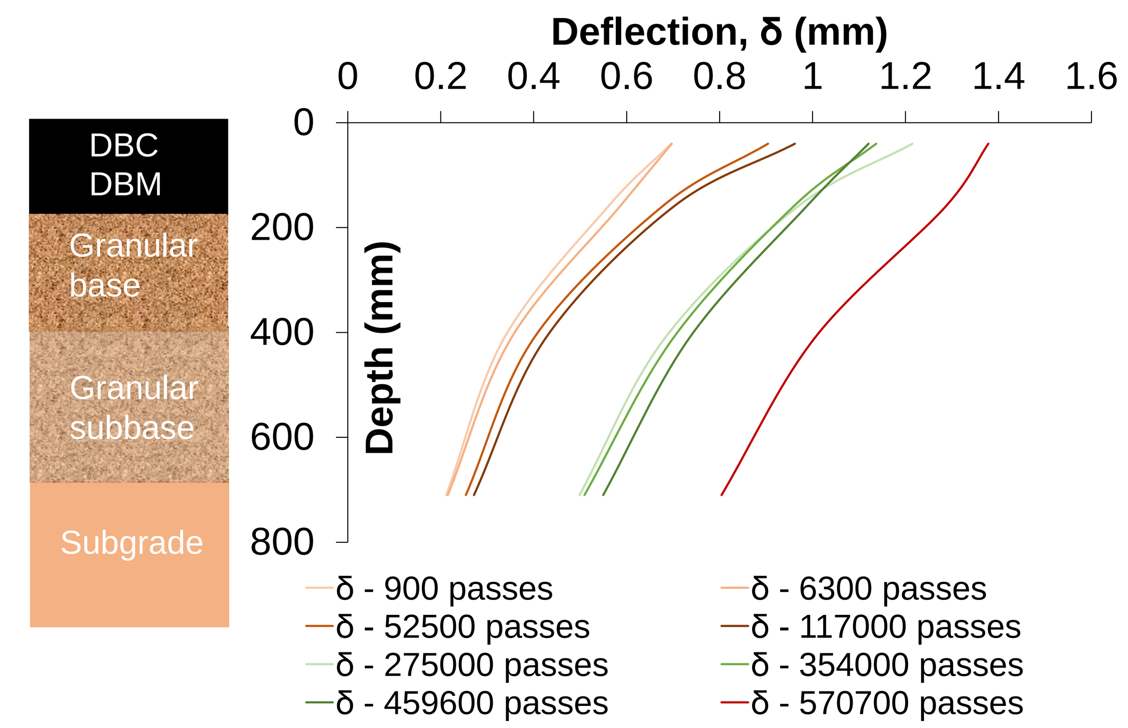


Figure 4: Deflections along the pavement depth

Falling Weight Deflectometer (FWD)

- Subgrade modulus is given by

$$E_o = I\frac{((1+\mu_o)(3-4\mu_o))}{2(1-\mu_o)}\left(\frac{S_o}{S}\right)\left(\frac{p}{\Delta_o t}\right)$$

- Temperature correction is applied by

$$y = 10^{-0.0002175(70^{1.886} - T^{1.886})}$$

Table 2: Elastic modulus of each layer

Asphalt layer modulus (MPa)		Base layer and subbase modulus (MPa)	Subgrade modulus (MPa)
20°C	5,513	258	75
35°C	1,698		

- The values obtained from FWD and the actual thickness was used to determine the vertical compressive strain at top of subgrade.

Results

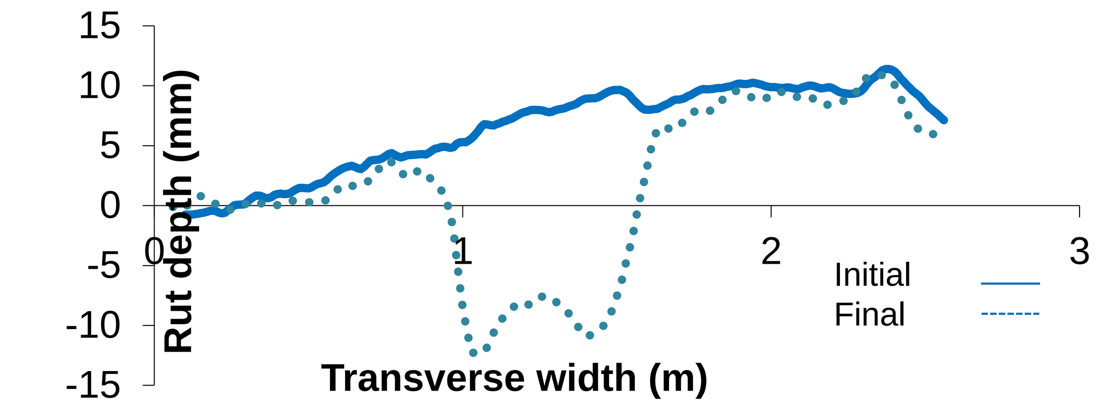


Figure 5: Deformation measured using Laser Profilometer

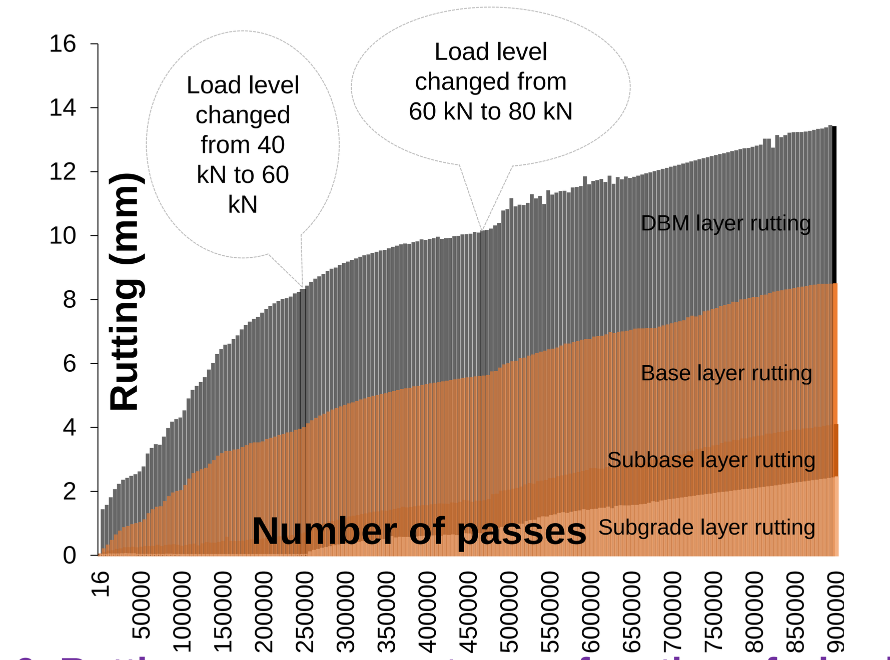


Figure 6: Rutting measurements as a function of wheel passes

Table 3: Vertical compressive strain on top of subgrade

Load (half axle) kN	IITPAVE Vertical compressive strain (μs)	MDD Vertical compressive strain (μs)
40	243	326-479
60	363	570 (constant)
80	480	>628

Conclusions

- The total rutting was 19.523 mm due to load applications of 8.88 million standard axles (9,33,000 passes).
- The contribution of bituminous layer rutting is 56.1 %, the base layer is 22.8%, the subbase layer is 8.2% and the subgrade layer is 12.9% which clearly suggest that rutting is taking place in all layers
- The result suggests the need for development of better transfer function for rutting as computed vertical compressive strain were found to be different from field values.

Acknowledgements

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