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Material, Design, Construction, Maintenance, and Testing of Pavement

Edited by
Don Chen, Ph.D.
Jeffrey Lee, Ph.D.
Wynand JvdM Steyn, Ph.D.

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MATERIAL, DESIGN, CONSTRUCTION, MAINTENANCE, AND TESTING OF PAVEMENT

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Preface

This Geotechnical Special Publication (GSP) contains 21 papers that were accepted and presented at the GeoChina International Conference on Sustainable Civil Infrastructures: Innovative Technologies for Severe Weathers and Climate Changes, held in Shandong, China on July 25-27, 2016. The overall theme of the GSP is material, design, construction, maintenance and testing of pavement, and all papers address different research findings of this theme. Major topics covered are engineering properties of pavement materials, design of flexible and rigid pavements, pavement performance evaluation, and test methods for pavement characterization. It provides an effective means of shearing recent technological advances, engineering applications and research results among scientists, researchers and engineering practitioners.

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Contents

Exploratory Study to Use Traffic Speed Deflectometers (TSD) for Project-Level Pavement Evaluations

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Abstract: ARRB Group has purchased a second-generation Greenwood Engineering Traffic Speed Deflectometer (TSD) and commenced data collection across Australasia in 2014. The TSD, fitted with extra ARRB Hawkeye equipment, can collect continuous deflection profile and surface condition data (such as cracking, rutting, roughness and surface images) at traffic speeds of around 80 km/h. While the TSD is traditionally seen as a network-level pavement evaluation tool, this paper presents an exploratory study of using the device for project-level pavement evaluation. Using linear-elastic mechanistic analysis software, theoretical surface basins were computed and compared with the TSD-measured deflection basins. This provides an insight into ways in which TSD results could be interpreted and utilised in routine pavement engineering. Limited theoretical models of TSD loading on a range of pavement profiles have been computed. Back-calculation software, EFROMD3, was used to highlight the promising potential to estimate in situ layer moduli via back-calculating from the TSD-measured deflection basins. Recommended future research is presented.

INTRODUCTION

The TSD is a pavement evaluation device, manufactured by Greenwood Engineering in Denmark, which measures the pavement surface deflection at traffic speeds. Following an initial trial of TSD technology (Kelley & Moffatt 2012), ARRB Group acquired a TSD in 2014, then was modified to include additional ARRB Hawkeye road condition monitoring sensors and logging systems. A schematic diagram of the TSD is shown in Figure 1. The device commenced deflection surveys in Australia (Queensland and New South Wales) and New Zealand in 2014 (Wix 2014). Deflection basins are computed using the integration of the area under the curve (AUTC) method (Muller & Roberts 2013). Six Doppler lasers located along the outer wheel path, at offset distances of 100, 200, 300, 450, 600, and 900 mm from the dual-axle, are analysed to obtain the deflection basin. Expressing the TSD data as a deflection basin provides the opportunity to compare the deflection basin with that of other devices and potentially allows for the use of the TSD data in current pavement analysis methodologies. Information provided by modern deflection testing devices goes beyond maximum deflection and curvature readings. An experienced engineer can assess the pavement structural capacity based on the shape of the deflection basin.

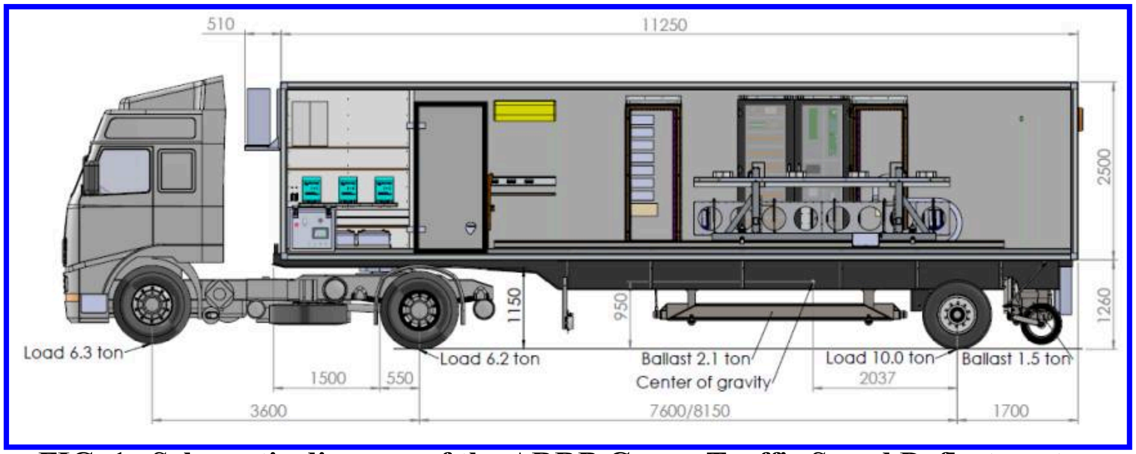

FIG. 1. Schematic diagram of the ARRB Group Traffic Speed Deflectometer.

Over 12,400 km of the Queensland state-controlled road network was surveyed between April and August 2014. The deflection data provided a continuous and cost-effective evaluation of the road pavement assets, which would not be possible using traditional deflection measurement devices. As such, the device is ideal for monitoring a road network and identifying road sections for repair and maintenance purposes. A second year of TSD surveying in Queensland was completed between April and August 2015. Based on data collected in Queensland, this paper presents the findings of a preliminary investigation of the potential utilisation of TSD-collected data in existing routine pavement engineering processes and procedures.

TSD and FWD Comparison

Given its long-established use, lots of experience has been gained in the use of Falling Weight Deflectometer (FWD) deflections. Therefore, as a first step to improving the understanding of the TSD, it is important to compare the TSD results with the FWD. There are fundamental differences (such as loading type, loading speed, measurement, and analysis technique) between the two devices. Therefore, it is expected that these differences may lead to different measured deflections and shapes of the deflection basin. There is currently limited modelling conducted to explore and explain such differences.

To date, limited 'side-by-side' correlation studies between the TSD and FWD has been undertaken in Queensland. A recent correlation study of TSD and FWD data has been conducted along the Centenary Highway in August 2015. TSD data was collected on 23 August, and the FWD testing conducted on 20 August. The Centenary Highway is a flexible, granular pavement with a sprayed seal surface. The section has a uniform 220 mm granular base over a 150 – 290 mm granular subbase. The in situ subgrade strength is variable along the carriageway. Figure 2 presents the maximum deflection (normalised to 50 kN) measured from the TSD and FWD that shows the similar trend between the two devices. It is noted that the measurements were reported at 10 m spacing along the outer wheel path of the slow lane. Currently, the TSD does not measure the deflections along the inner wheel path, which limits the application of the device for projects where substantial differences in deflections are expected across the driving lane. Multiple FWD load levels (i.e. 40, 50 and 60 kN) were used.

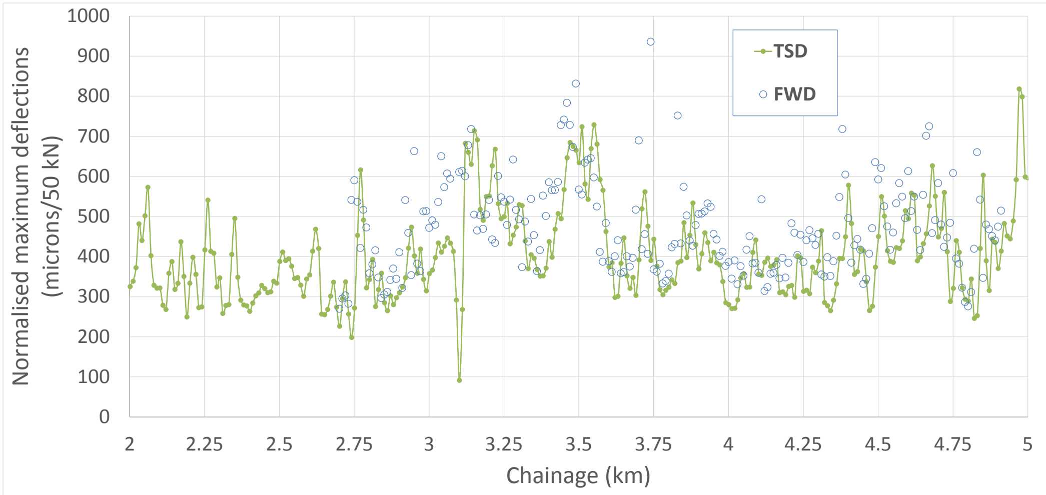

FIG. 2. Comparison of TSD and FWD deflections (normalised to 50 kN) measured on a granular pavement along Centenary Highway.

Deflection basins measured by the TSD and FWD at two discrete locations are shown in Figure 3. The Doppler lasers in the TSD measure the velocity slope reading at six locations, and the readings were analysed using the AUTC method. The method produces a deflection basin (as shown in Figure 3) and the FWD deflection basin measured at the same location is also presented.

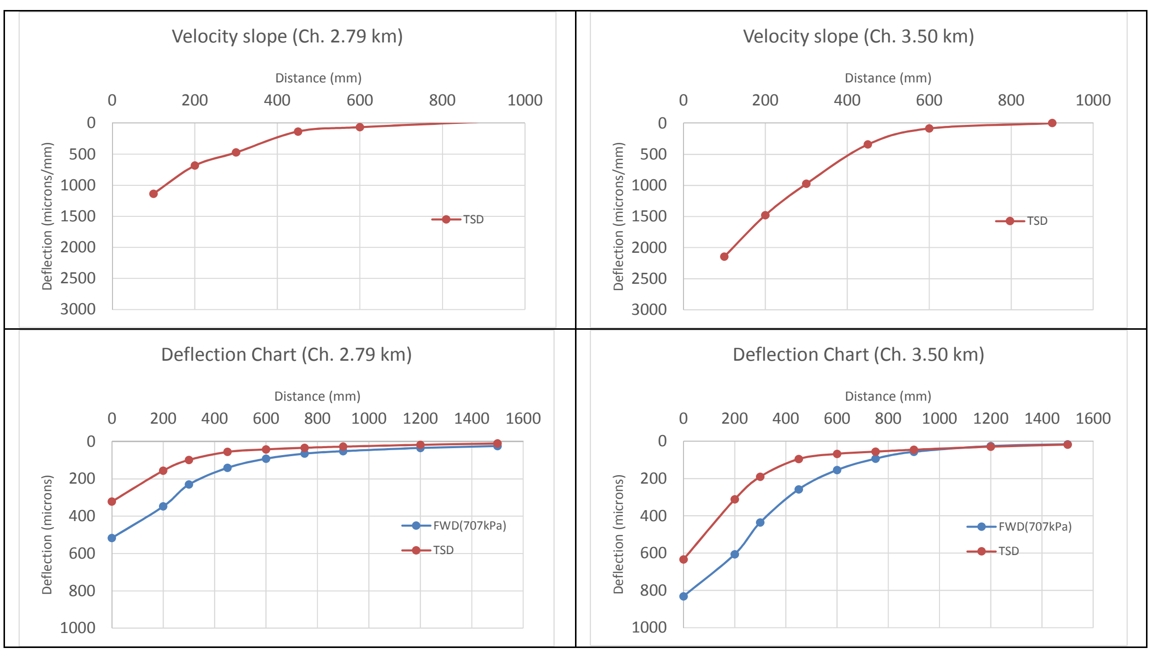

FIG. 3. Deflection basin from FWD and deflection basin and velocity slope from TSD on a granular pavement along Centenary Highway.

At a normalised load of 50 kN (707 kPa contact pressure over the FWD circular plate), the FWD maximum deflection is higher than the one reported by the TSD (applying a notional 50 kN load via a set of dual-tyres). This difference can also be seen in a layered-linear-elastic analysis, conducted using CIRCLY software from Mincad Systems. In that theoretical modelling the results show that for a granular pavement, a higher maximum deflection is expected from a FWD than the maximum deflection from a TSD dual-tyre half axle. The deflections generally converge at larger sensor offset because the strain experienced by the subgrade would be similar whether the load was applied from an FWD or a TSD. This trend is also shown in Figure 5(a) where the deflection from both devices converges past an offset of 500 mm.

Theoretical modelling of TSD and FWD surface deflections

In Australia, CIRCLY is the principal software used for routine pavement analysis and thickness designs. CIRCLY conducts response-to-static-load calculations based on a linear elastic model. While this model might be too simple for precise modelling of a fast-moving dynamic load over non-linear pavement material, it is a good and simple starting point to examine theoretical TSD surface deflection basins for different pavement structures. Figure 4 shows the loading configurations of a TSD and an FWD. During operation, the ARRB TSD has a nominal load of around 50 kN, although this load does vary with travel as a result of dynamic movements of the suspension system. Two load cells are installed in the TSD rear axle, however to date load measurement is typically not considered – i.e. TSD deflections have not been load normalised. The FWD details shown in Figure 3 correspond to a 50 kN loading drop.

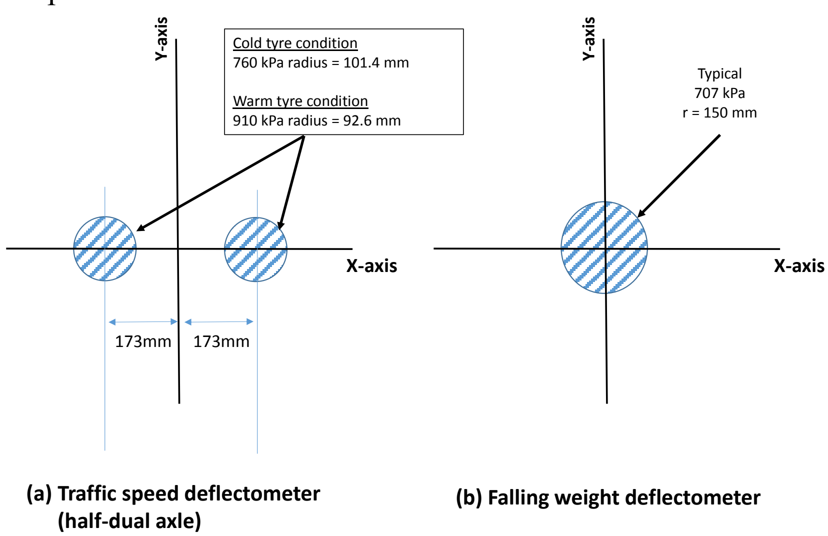

FIG. 4. Typical loading configuration used in forward modelling of TSD and FWD.

Figure 4 shows the theoretical surface deflection computed for the TSD and FWD for three different pavement types – a granular pavement, a full-depth asphalt pavement, and a cement-treated base pavement. In this theoretical analysis, it is noted that the TSD produces a smaller maximum deflection than the FWD maximum deflection. On