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Characterization of structural conditions for pavement rehabilitations

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HIGHLIGHTS

- TPAD has been used successfully to identify problematic areas with very poor load transfer.
- GPR is integrated into TPAD and able to detect trapping moisture in the subsurface layers.
- The responsible district has implemented TPAD results for pre-overlay treatment.

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ABSTRACT

For concrete pavements it is critical to identify weak spots and locations with very poor load transfer efficiency and then to apply localized repairs before placing a structural overlay. Collecting a continuous deflection profile is the most efficient way to identify those locations. The Texas Department of Transportation's Total Pavement Acceptance Device (TPAD) has been used successfully on two field projects with main goal of identifying these problematic areas. TPAD is an integrated nondestructive testing tool and it collects continuous deflections at approximately 50 mm intervals with three rolling geophone sensors while traveling over the pavement at 2 mph. Empirical threshold values have been established to identify and prioritize the problematic areas. Refinements to the threshold values can be made with additional field performance monitoring data. In addition to continuous deflections, the TPAD unit also collects continuous Ground Penetrating Radar (GPR) data. In a project on IH 20, the GPR data presented clear evidence that there are wet areas beneath the existing concrete slabs due to clogged edge drains. Trapped moisture is one of the main causes for the recurring failures observed on IH20.

On the jointed concrete pavement on Loop 12 in Dallas, five different short sections with high deflections were successfully identified. The responsible district has implemented recommendation for pre-overlay treatment on those five short sections through full depth repairs. The TPAD data provides quantifiable and defensible data for selecting the required repair areas before the overlay to minimize premature failures. With its continuing utilization and additional field performance monitoring, it is anticipated that the refinements to the threshold values for TPAD analyses can be made.

1. Introduction

A large portion of Texas Department of Transportation's (TxDOT's) multi-billion dollar budget is used to rehabilitate damaged concrete pavements many of which have far exceeded their design lives. Reflective cracking is one of the main distresses in HMA overlays of concrete pavements. The main objective of pavement rehabilitation design is to provide a cost-effective solution that addresses the deficiencies of the pavement and the ride quality while meeting all of the imposed constraints such as available funding, constructability, and lane closures. This objective cannot be achieved without conducting a thorough pavement evaluation to determine the underlying causes and the extent of the pavement's deterioration. When hot mix asphalt (HMA) overlays are placed on the deteriorated pavements, the cracks and joints in the existing concrete pavement structure may reflect to the surface shortly after placement, and reflective cracking is one of the main distresses for HMA overlays on concrete pavements [6,9]. Although reflective cracking has been studied extensively for many years, it

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still is an issue and responsible for poor performance of the rehabilitated pavements, which quite often results in a shorter than anticipated performance period and repeated rehabilitation treatments.

Nam [11] and Lee et al. [10] indicated that the goal of determining load transfer efficiency and identifying problematic areas with structural deficiencies, which could lead to reflective cracks in overlay, can be achieved efficiently and reliably through the utilization of continuous deflection profiles. Continuous deflectometers should be able to measure pavement bearing capacity without the need for the vehicle or the measuring device to remain stationary [7,5]. A new and multifunction non-destructive/non-intrusive pavement testing device, Total Pavement Acceptance Device (TPAD), has been recently develop and implemented with TxDOT funding. The predecessor of the TPAD is the rolling dynamic deflectometer (RDD). The RDD has provided TxDOT with valuable pavement structural condition information for the last two decades from continuous pavement deflection profiles [12,1]. During the last 10 years, it was found that continuous pavement deflection profiles can be more effectively used when combined with other nondestructive testing devices. The current TPAD system also incorporates Ground Penetrating Radar (GPR), pavement right-of-way and surface condition video camera, pavement surface temperatures, and Distance Measurement Instrument (DMI), as shown in Fig. 1.

One high-speed deflectometer device from Greenwood Engineering has been used by several institutions is Traffic Speed Deflectometer (TSD) [8]. The Danish Road Institute tested its main network using TSD each year from 2005 to 2007. The daily survey coverage for TSD is approximately 170–225 km (105–140 miles). The TSD collects raw data at approximately 1000 Hz, but there is significant random noise in this raw signal. The TSD sensors measure deflection velocity, not displacement, so the measurements cannot directly provide either the full deflection basin or the maximum deflection value.

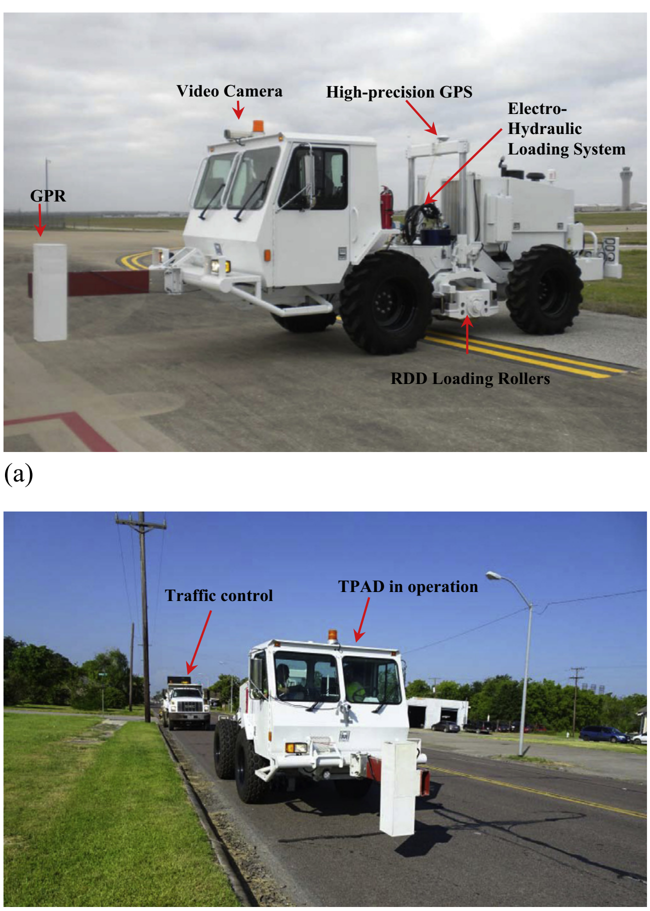

Fig. 1. Total Pavement Acceptance Device (TPAD): (a) TPAD with Key Components and (b) TPAD Operation on a Pavement.

Research results from Nam [11] and Chen [2] have demonstrated that continuous deflections are a good indicator of reflective cracking potential. Fig. 2 illustrates an example of the continuous deflection profiles for two different jointed concrete pavements. Chen [3] utilized the RDD for selecting the optimum rehabilitation strategies as the extent and degree of reflective cracking heavily depends on the underlying slab stability (vertical movements under load). For example, a TxDOT District staff has observed accelerated deterioration and poor ride quality on IH35 in the last two years, prompting a search for a longer lasting rehab strategy. The existing IH35 section consists of 75 mm of HMA and 250 mm of Continuous Reinforced Concrete Pavement (CRCP). The original CRCP was built 45 years ago. The HMA was placed approximately 10 years ago. Full depth repairs have been used through the years to repair localized failures and maintain drivable condition. However, pumping and localized failures continue to occur, as shown in Fig. 3A. The distress shown on Fig. 3 is not only limited to deterioration with the surface layer. Based on the previous experience, the base and subbase needs to be strengthened to minimize recurring distress. Otherwise the repair will not last for more than 2 years. The ride quality is very poor, with average IRI exceeding 3.16 m/km (200 in./mile). District personnel would like to improve the ride quality and to rehab the section by overlaying it. Thus, the RDD was utilized to identify the weak spots that need to be treated separately before using an overlay to improve ride quality. Otherwise, the untreated weak spots may fail prematurely. Fig. 3B shows continuous *W1-W3* deflection profiles with a few locations exceeding 0.25 mm (10 mils). Where W1 is the deflection measured between the loading wheels and W3 is the deflection measured two feet in front (610 mm). Fig. 3A shows the surface distress conditions at a location where deflection exceeds 0.25 mm (10 mils). A recommendation was provided to the District to repair (with dowel bar retrofit or slab replacement) all locations where the *W1-W3* deflections exceed 0.165 mm (6.5 mils), and then overlay the entire section with HMA. The RDD data provided quantifiable and defensible data for selecting the weak spots for separate treatments before the overlay to minimize premature failures.

The information provided by the TPAD system can help in both of these critical areas: (1) to develop the optimum rehabilitation strategy and (2) to measure the structural adequacy of both recent repairs and the structural uniformity of newly constructed pavements. The TPAD is the only known project level rolling deflection system in the world providing this critical information to pavement designers. This system is at least 50 times faster than traditional stop-and-go deflection measuring systems such as the Falling Weight Deflectometer (FWD) [13]. TPAD provides 100% coverage instead of discrete locations as offered by FWD. With its continuing deployment and utilization, it is anticipated that TPAD will become the critical tool for assisting TxDOT in making multi-million dollar pavement rehabilitation/repair decisions. The TPAD produces a continuous deflection profile and integrated video that provide surface condition for user friendly and reliable analysis.

2. Total pavement acceptance device (TPAD)

The Total Pavement Acceptance Device (TPAD) is an integrated nondestructive testing tool for measuring the structural strength,