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Design improvements to enhance the performance of thin and ultra-thin concrete overlays in Texas

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HIGHLIGHTS

- Improved designs for thin concrete overlays have been implemented.
- Saw-cut joints should stay away from the wheel paths.
- Transition slabs should increase by 75 mm over TWT thickness.

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ABSTRACT

Over the years, the design of thin and ultra-thin concrete overlays (TWT and UTW) has improved. The performance of TWT and UTW sections built with various designs in Texas has been evaluated, with the goal of further improving design standards and construction specifications. Distresses observed in TWT and UTW sections built prior to 2005 were associated with (1) panel size and layout, (2) transition areas, (3) sliding of slab panels, and (4) defects in existing HMA. Design improvements were made in 2011 to mitigate those distresses, which included placing joints away from wheel paths and the use of continuously reinforced concrete pavement (CRCP) or thickened slabs at transition areas. Regardless of the slab thicknesses used, the panel layout should be 1.83- × 1.83-m (6- × 6-ft). The goal is to have saw-cut joints away from the wheel paths, and thus reducing wheel load stresses in concrete slabs. The increase in curling stresses due to the use of this slab size compared with smaller size slabs appears to be offset more by reduced wheel load stresses. Comprehensive characterization of the existing HMA condition should be made to identify and address hidden defects before the TWT or UTW overlays. Even with some distresses, TWT and UTW sections in Texas have performed satisfactorily with oldest sections having been in service for more than 14 years with minimal repairs required. No distresses have been observed in two TWT projects built in 2011 and 2012 with the improved design practices.

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1. Introduction

Traffic interruptions at intersections due to frequent repair or rehabilitation activities could cause traffic delays and high user cost. Fig. 1 shows the typical distresses (deep rutting and shoving) at intersections. Several districts at the Texas Department of Transportation (TxDOT) indicated that rehabilitation activities were required yearly for those problematic intersections. Thus, it is desirable to build a durable and reliable pavement system at those intersections that requires minimum repair and rehabilitation activities. Thin and ultra-thin concrete overlays (also known as whitetoppings) are a pavement system of Portland cement concrete (PCC) placed on hot mix asphalt (HMA) concrete pavement. Concrete overlay with slab thickness ranging between 50 and 100 mm (2-in and 4-in) is commonly referred to as ultrathin whitetopping (UTW), and that with concrete slab thickness between 100 mm (4-in) and 200 mm (8-in) is referred to as thin whitetopping (TWT). Whitetopping is constructed with thinner slabs with shorter joint spacing with no tie bars and no joint sealing. Whitetopping has small joint spacing in order to minimize

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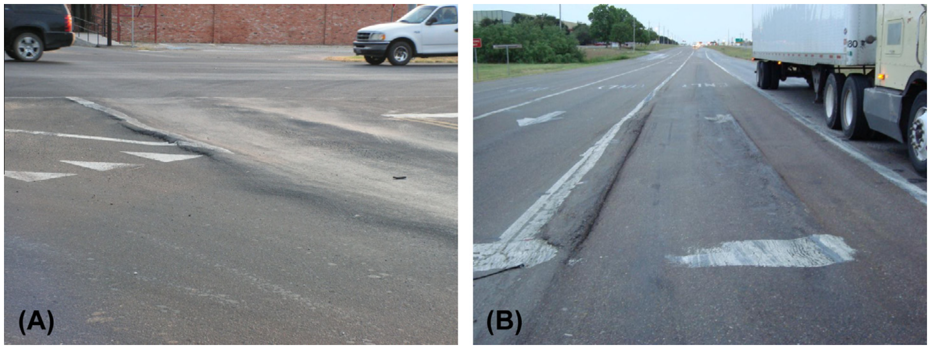

Fig. 1. Typical Distresses (Deep Rutting and Shoving) at HMA Intersections (A) US 69 (B) US83.

stresses from wheel load applications as well as temperature and moisture variations. In the current rigid pavement design methodology, the support condition as represented by the modulus of subgrade reaction (k-value) is considered to have minor effects on required slab thickness. It is because the stresses at the bottom of concrete slabs and at the top of the subbase are not sensitive to k-value, primarily due to the high stiffness of the concrete slab and relatively large thickness of concrete slabs used in modern PCC pavements. Although the evaluations of PCC pavements in Texas do not necessarily corroborate this theory, it appears that the stress level on top of the subbase due to the applications of wheel loading is quite low [6], at least from a theoretical standpoint. However, the same philosophy cannot be applied to the whitetopping system. First, the slab thickness for whitetopping is smaller than that used in normal PCC pavement. Second, the short joint spacing used in whitetopping does not fully utilize the benefits of the bending action of the thick PCC slabs. The resulting effects are that the stress level on top of the HMAC pavement is greater than that on top of the subbase in traditional PCC pavement. On the other hand, the structural capacity of the existing HMA pavement, even in deteriorated condition, might be superior to that of a slab support system used in new concrete pavement construction. Accordingly, the use of thinner slabs with smaller joint spacing on deteriorated HMA pavement could be a reasonable and viable pavement system.

A number of state transportation agencies including TxDOT have used UTW and TWT overlays. Table 1 provides a list of UTW and TWT projects in Texas built to date. The earliest UTW project was completed in 2001. The performances of several UTW and TWT projects show some variations in distress types and levels. Some UTW and TWT projects have exceeded ten years of life expectancy with minimum maintenance, as shown in Fig. 2. However, at other UTW and TWT projects, severe corner cracking was developed under the wheel paths on the driving lane, as shown in Fig. 3. In other projects, distresses at transition areas were more pronounced (see Fig. 4). The joint spacing and saw cut pattern have a significant impact on performance as it determines the wheel loading condition in the slabs [6,1]. Joints placed under or near the wheel paths could cause cracking in TWT and UTW projects, due to corner or edge loading condition. In addition, field observations indicated that cracks were observed at slabs with an acute angle of the saw-cut and at the transitions between the TWT and the existing HMA pavements.

For a good long-term performance, the UTW and TWT overlays must bond to the underlying asphalt so that the two layers respond in a monolithic manner, thereby reducing load-related stress [9,1]. If designed and constructed properly, UTW and TWT overlays could help in mitigating the adverse effects associated with frequent and costly HMA pavement repairs and rehabilitations. In most cases, a bond between the new PCC and existing HMA layers is not only assumed during design, but specific measures are taken to ensure good bond during construction. The success of this bond, leading to composite actions of whitetopping, has been found to be critical to a good performance of this composite pavement system.

The main purpose of this paper is to document and improve the performance of the UTW and TWT projects in Texas. The performance of UTW and TWT projects in Table 1 was evaluated visually and, in one project, non-destructive testing was also utilized. The investigation provided the performance feedback needed to improve pavement performance. Interestingly, the results from the condition survey indicated that there was no noticeable distress caused by high shear stresses at intersections. By default, full bonding between layers was used in the design. It appears that traditional design and construction requirements have addressed potential high shear stresses at intersections.

The oldest UTW project in Texas was constructed in 2001 and showed some distresses. In 2011, TxDOT developed improved UTW and TWT design methods and construction specifications based on a research study, and two TWT projects were constructed in 2011 and 2012 to validate the improved designs. The performance of the two TWT projects with the improved designs was evaluated and the findings are also discussed in this paper.

2. Key design features – literature review

Base on field condition surveys, most distresses in UTW and TWT projects in Texas were observed near the transition areas. In addition, some of the distresses appear to be due to poor joint lay-

Table 1
Ultrathin Whitetopping (UTW) and Thin Whitetopping (TWT) Projects in Texas.

District	CSJ	Location	Completion date	UTW or TWT thickness	Slab size
Abilene	6084-09-001	BU 83D & N. 2nd St. Intersection	June 2003	4″	3′ × 3′
Childress	0043-04-063	US 287 & FM 91 Intersection	Apr. 2004	5″	5′ × 5′
Odessa	1188-02-058	Loop 250 (Midkiff Rd to SH 349)	Sep. 2001	3″	3′ × 3′
Odessa	1188-02-059	Loop 250 (SH 158 to Midkiff Rd)	May 2005	3″	3′ × 3′
Paris	6234-09-001	US 69 & SH 19 Intersection	May 2012	7″	6′ × 6′
Paris	6220-02-001	Loylake Rd & US 75	July 2011	6″	6′ × 6′

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