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FIELD ASSESSMENT AND ANALYTICAL MODELING OF ULTRA THIN WHITETOPPING

PROBLEM STATEMENT

Ultra Thin Whitetopping (UTW) is a technique for resurfacing deteriorated asphalt pavements: very thin concrete slabs (2" to 4" thick) are placed on old asphalt pavements to form bonded (or partially bonded) composite pavements. The reduction of thickness is justified by the use of high quality concrete with relatively high strength, shorter joint spacing, and bonds between the concrete and existing asphalt pavement. UTW has been a rehabilitation option for years, especially for deeply rutted intersections.

The mechanical behavior of UTW concrete overlay under various loading and environmental conditions can best be investigated by using a rigorous mechanistic approach such as the finite element (FE) method. A well calibrated FE model could provide insight into the effects of many design parameters such as layer thickness, addition of concrete fiber, subgrade and base stiffnesses, panel size, and depth of joints. Additional environmental factors can also be simulated using FE modeling. While these parameters can be studied without comprehensive field testing or full scale UTW prototypes, field testing and real time data collection on the mechanical behavior of UTW are extremely valuable for establishing a realistic FE model.

OBJECTIVES

Researchers followed the FE approach, testing three tracks constructed at the FDOT State Materials Office. Slab thickness, joint spacing, and base stiffness were among the variables included in the study, whose objectives were to:

1. Conduct field tests and measurement on typical overlays.
2. Investigate current methods of analysis.
3. Use numerical techniques (FEA) to study different UTW designs to compare to the field testing measurements.
4. Study the effect of slab size and bonding between UTW and the asphalt layer.
5. Develop computer software to design UTW according to the FDOT methodology.

FINDINGS AND CONCLUSIONS

Several finite element models were examined and calibrated based on full scale field testing. Three full-scale test tracks of UTW were constructed with various design parameters including overlay thickness, pane size, and base layers. The three tracks were tested using a moving truck load, where pavement stiffnesses were determined at different cyclic loadings.

For Test Track I, a 4" thick UTW was placed on an existing pavement composed of 1.5" asphalt pavement and 6” concrete base. Test Track II consisted of 3” and 4” thick sections. Test Track III was built with a 2” thick concrete overlay. Joint spacings ranged from 4’ to 6’ for Test Tracks I and II, and 3’ x 3’ to 12’ for Test Track III. Fibrillated Polypropylene fibers were used in Tracks I and II. Monofilament Polyolefin fibers were used in Track III. High early strength concrete mixture was used for all of the tracks.

The UTW overlays were subjected to approximately 50,000 (18-kip) Equivalent Single Axle Loads (ESALs) using a truck loaded with concrete blocks. The Falling Weight Deflectometer (FWD) test results showed a significant reduction in the surface deflection—75%, 78%, and 46% for Test Tracks I, II, and III, respectively--which indicated an improvement in the structural capacity of the pavement after UTW placement. Frequent condition surveys showed good performance of the three test tracks. Structural cracking was noticed on Track Ill with a 12’ x l2’ panel. In general, the encouraging performance of the test tracks was attributed to the method of UTW preparation and to the performance of the underlying pavement layers.

Analytical modeling resulted in similar conclusions. Researchers found that the reduction of the bond strength, the increase in the panel size, and the reduction of the overlay thicknesses contributed to the development of the UTW structural cracks and thus jeopardized the performance of the UTW. Bond strength between the UTW and the asphalt layer was essential for the long term performance of the layer.

Shear strength at the UTW asphalt interface should be at least 200 psi (Iowa shear test), and the UTW should be designed using short joint spacings. This research showed that the preferred joint spacing for 3” and 4” thick UTW should be 4’ to 6’. The joint spacing for 2” thick UTW should not exceed 4’. The effect of fibers on the performance of the UTW could not be determined. Sections using plain concrete and those using fiber concrete performed equally well. Previous research, however, has shown that plastic fiber prolongs stages I and II of the fatigue life expectancy of concrete beam samples, which suggests that more truck load repetitions might have been needed to establish the testing results of the concrete samples.

Fibrillated fibers were included in the concrete for the sections on the west side of the weight platform and plain concrete was used on the east sections of the test tracks. The joints on the east section were sealed with silicone sealant while the joints in the west section were left unsealed. FWD tests from 60 locations along the length of the traffic lane showed an average decrease in the UTW surface deflection of about 63%. Variability in asphalt and UTW thicknesses did not appear to play a major role in the magnitude of the FWD deflections. No significant differences were observed in the FWD deflections in the various UTW sections. Likewise, the panel dimensions did not impact the magnitude of the deflections. After six months, the FWD tests showed deflections to be 56% lower than they had been on the original asphalt layer, which indicates that the pavement was still acting as a composite element of two bonded layers possessing sufficient support to carry the high volume of heavy trucks.

During a one year period, only 5.5 % of the 1800 panels in the traffic lane developed cracks, the majority of which were corner cracks. De-bonding at the UTW-asphalt interface was the most likely cause of the corner cracks. Late sawing of joints was the main contributor to the curling and de-bonding of the corners.

Software was developed to calculate the stresses and strains in the concrete and asphalt, respectively, utilizing input parameters derived from the existing pavement layers and the anticipated UTW joint spacing and concrete properties. The program determines the least possible thickness needed for the UTW, with the condition that the total concrete and asphalt fatigues should be less than 100%.

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