Summary of Final Report, BC 354-51
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EVALUATION OF PERFORMANCE OF ULTRA-THIN WHITETOPPING BY MEANS OF HEAVY VEHICLE SIMULATOR (ANALYSIS, PLANNING & DESIGN PHASE)

PROBLEM STATEMENT

Ultra-thin whitetopping (UTW) is a pavement rehabilitation technique in which a thin concrete overlay (2 to 4 inches thick) is placed over an existing asphalt pavement. Many states and local agencies have conducted experimental studies to evaluate the performance of UTW. Preliminary evaluations of these recently constructed UTW projects have shown that UTW is a viable rehabilitation method for asphalt pavements. The Florida Department of Transportation (FDOT) constructed a UTW test pavement at Ellaville weigh station along I-10 in north Florida in 1997 to evaluate the applicability of UTW in Florida. However, the performance of these test sections was less than satisfactory (i.e., some early cracking on the concrete surface). Investigation of the causes of problems on these UTW sections have indicated that they were under-designed for the traffic at the Ellaville Weigh Station. There is a need to analyze and field-test the effects of important factors affecting the performance of UTW pavements and, subsequently, to develop a reliable design method for UTW pavements for Florida conditions so that this method of rehabilitation can be applied effectively in Florida in the future.

OBJECTIVES

The FDOT Materials Office has recently acquired a Heavy Vehicle Simulator (HVS) and constructed an Accelerated Pavement Testing (APT) facility. The HVS can simulate 20 years of interstate traffic on a pavement test section within a period of one to four months. The APT facility will be used to evaluate the long-term performance of various UTW designs in Florida so that an effective design procedure for UTW pavements in Florida can be developed. The main objectives of this project include the following: (1) identify important factors affecting the performance of UTW pavements, (2) model and analyze the behavior of UTW pavements, (3) select for evaluation UTW designs applicable to Florida conditions, and (4) design an experiment using the APT facility to evaluate these UTW designs.

FINDINGS AND CONCLUSIONS

In this project, a 3-D finite element model was developed for the stress analysis of UTW pavements. The results from the 3-D model were verified by the results of similar analyses using a reliable 2-D finite element program, FEACONS. The 3-D model was used to perform a parametric analysis to determine the effects of a few important pavement parameters on the maximum load and temperature-induced stresses in UTW pavements under typical Florida conditions.

The maximum load and temperature-induced stresses in the concrete layer were observed to increase significantly as (1) asphalt thickness decreases, (2) asphalt stiffness decreases, (3) concrete thickness decreases, (4) concrete stiffness increases, (5) base stiffness decreases, (6) concrete panel size increases, and (7) temperature differential in the concrete becomes more negative. The maximum stresses in the concrete were not significantly affected by changes in subgrade modulus.

The maximum shear stresses at the concrete-asphalt interface were observed to increase significantly as (1) asphalt thickness decreases, (2) concrete thickness decreases, (3) base stiffness decreases, and (4) concrete panel size increases. The following parameters were observed to have little effects on the maximum interface shear stresses: (1) asphalt stiffness, (2) concrete stiffness, (3) temperature differential, and (4) subgrade modulus.

While the maximum stresses increase as the applied load increases, the percent increase in stress is slightly less than the percent increase in load, because as the load increases while the contact pressure remained the same, the contact area is increased. An increase in contact area helps to spread the load more evenly over the UTW panel and, thus, to reduce the stresses.

The developed 3-D model was also used to analyze the UTW test pavement sections at the Ellaville Weigh Station. The high maximum computed stresses in the poor performing UTW sections at this weigh station seem to explain their poor performance with high percentages of cracked slabs.

Based on the analysis of the UTW pavements, 18 UTW designs applicable to Florida conditions were selected for consideration for accelerated field-testing using the HVS using a 12-kip super single tire. Stresses in these UTW pavements caused by a 12-kip wheel load with a contact pressure of 120 psi under two different temperature conditions were computed using the developed 3-D model. The two temperature conditions considered were (1) no temperature differential and (2) a temperature differential of -5 ºF. The following are the computed stresses for each of the UTW designs: (1) the maximum positive principal stress, maximum negative principle stress, maximum tensile stress in the x direction, and the maximum shear stress in the concrete layer, and (2) the maximum principal stress in the asphalt layer.

The recommended tests, measurements, and instrumentation on the UTW test sections are presented in the final report. Strain gauges are to be placed at locations on the UTW layer where the computed load-induced stresses are at or are close to maximum values. Thermocouple wires are to be used to monitor the temperatures at the surface, middle, and bottom of the concrete layer, and at the middle and bottom of the asphalt layer. Whitmore plugs are to be installed at the concrete panel joints to measure concrete panel movements and joint openings.

BENEFITS

This research provides the prerequisite information needed to set up a sound and realistic APT simulation of the actual in-service performance of the UTW rehabilitation process, and, thus, to obtain meaningful and properly supported results. The use of APT simulation will result in cost savings (i.e., costs associated with setting up and maintaining in-service experimental sections) and in the avoidance of potential inconveniences to the traveling public, not to mention obtaining results in a significantly shorter time than could be achieved through in-service testing.

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