TEXAS TECH UNIVERSITY
Multidisciplinary Research in Transportation

PROJECT SUMMARY

Texas Department of Transportation

0-6910: Development of Proper Overlay Type and Designs for PCC Pavement

Background

As of 2016, TxDOT was managing a total of 16,327 lane miles of Portland cement concrete (PCC) pavement, which represents an important asset to TxDOT. As PCC pavements in Texas built in the 1960s through 1980s have already exceeded or are approaching the end of their design lives, many of these projects will require some form of rehabilitation. Considering the expected steady increase in future truck traffic, PCC overlays represent one of the best options for that rehabilitation. Currently, guidelines for applying PCC pavement overlays to PCC pavement focus on an overlay slab thickness determination, but do not provide clear directions on (1) whether the existing PCC pavement is a good candidate for concrete overlay, or (2) which overlay type—bonded concrete overlay (BCO) or unbonded concrete overlay (UBCO)—is appropriate. Sound guidelines are needed for the selection of an optimum overlay type, especially for continuously reinforced concrete pavement (CRCP) overlays, which could extend the performance period of structurally deficient PCC pavements in Texas at a reasonable cost.

What the Researchers Did

Three primary tasks conducted in this study were (1) the evaluations of PCC overlay performance of various BCO and UBCO projects built in Texas, (2) the development of BCO design procedures based on mechanistic-empirical principles, and (3) the development of design guidelines for the selection of an optimum overlay type and specifications. The structural behavior and performance of PCC overlays were investigated by deflection testing, bond strength testing, and material property evaluations. Three-dimensional finite element analyses were conducted to investigate structural responses of various PCC overlay systems under wheel and environmental loadings. Based on the analysis results and field performance of PCC overlays, a BCO design program was developed. For the UBCO system, detailed analyses were conducted to evaluate the soundness of the AASHTO 93 design procedures. To facilitate the implementation of the research findings as well as to help TxDOT engineers select an optimum overlay type, this study compiled and analyzed extensive information to develop deflection threshold values for proper overlay type selections..

What They Found

The findings from the extensive field evaluations and mechanistic analyses of PCC overlay projects and data analyses are summarized as follows:

- The performance of CRCP BCO on CRCP varied quite substantially, with some sections providing excellent performance under heavy traffic for more than 30 years, while some sections have failed within a few years, requiring additional rehabilitation. In general, a positive correlation has been observed between overlay thickness and long-term performance, although there are exceptions.

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- The performance of CPCD UBCO on CPCD has been excellent, with almost no distresses observed after more than 25 years of heavy truck traffic. Part of the reason for the excellent performance is that the pavement was over-designed (overlay slab thicknesses of 10 inches and 11 inches).The quality of the interlayer material and construction is also important, since the deterioration of the interlayer material increased slab deflections. Another important finding is that the transverse contraction joint (TCJ) in the overlay should be at the same location of the TCJ in the existing slab. A crack was observed where overlay TCJ was placed a few inches away from the TCJ in the existing slab.
- Bond strength testing conducted in BCO projects indicated a positive correlation between bond strength and BCO performance. However, what's more significant is the correlation between bond failure plane during bond strength testing and BCO performance. In projects with an excellent performance, the failure planes during bond strength testing were not at the interface; rather, they were all either within the existing slab or in the overlay. On the other hand, in one project with poor performance, all the failure planes were at the interface between overlaid and existing concrete slabs.
- The satisfactory performance of CRCP BCO on CPCD showed this pavement system has a good potential for rehabilitation of deteriorated CPCD.
- Assumptions made in the AASHTO 93 design methods for UBCO are not reasonable and result in over-design of slab thicknesses. More specifically, the assumption of identical concrete stresses due to wheel loading at the bottom of the overlay, existing slab, and equivalent slab is technically erroneous. The exponent value derived from this assumption, which is 2, is not reasonable; the value should be reduced to 1.4.
- For the selection of an optimum overlay type, accurate evaluation of the structural condition of existing pavement is important. Slab deflection was determined as the best indicator of the structural condition of the existing pavement. Based on the field performance, 7 mils was selected as a threshold value for 4-inch or thicker CRCP BCO on 8-inch CRCP. For CRCP BCO on deteriorated CPCD, 20 mils was selected as a threshold value for 7-inch CRCP BCO.

What This Means

For a satisfactory performance of CRCP BCO on CRCP, (1) the structural condition of the existing pavement should be such that the maximum deflection should not exceed 7 mils, (2) good interfacial bond strength should be provided, (3) adequate overlay slab thickness should be selected, and (4) the quality of the construction and materials should be adequate.

The current CPCD UBCO on CPCD design procedure in the AASHTO 93 results in unnecessarily conservative slab thickness, primarily due to the errors in the assumption. The design equation should be modified in accordance with the recommended exponent value of 1.4.

The implementation of the threshold values and draft special specifications is expected to improve the performance of PCC overlays in Texas.

For More Information

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