Project Summary
Texas Department of Transportation

0-5832: Develop Mechanistic/Empirical Design for CRCP

Background

Currently, TxDOT uses the AASHTO 93 Design Guide for the slab thickness design of continuously reinforced concrete pavement (CRCP). The AASHTO 93 Design Guide was developed based on the AASHO Road Test, where JCP (jointed plain concrete pavement) was the major pavement studied; CRCP was not included in the study. There were also a limited number of wheel loading applications studied. From a purely technical standpoint, because the mechanisms of distresses in JCP are quite different from those in CRCP, the AASHTO 93 Design Guide is not appropriate for the design of CRCP. With ever-increasing traffic on major highways in Texas where CRCP is widely used, there is a need for a more mechanistic-empirical (ME)-based pavement design procedure for CRCP. An ME-based pavement design method will allow TxDOT to optimize pavement structures to best utilize the limited financial resources available. The two primary distress types in CRCP, punchout and spalling, must be minimized.

What the Researchers Did

The primary distress type in CRCP due to structural deficiency is punchout. To identify the mechanism of punchout, field evaluations were conducted which included coring, deflection testing using falling weight deflectometer (FWD), and other non-destructive testing. Once the punchout mechanism was identified, mechanistic modeling was performed using a 3-dimensional finite element program. Another important element in the ME-based pavement design procedures is the accuracy of a transfer function. A transfer function was developed using the data from TxDOT PMIS. A CRCP design program based on ME principles was developed, called TxCRCP-ME, along with a user's guide for the program. Sensitivity analysis was conducted to evaluate the effects of input variables and the reasonableness of the results. For the spalling issue, extensive field evaluations were conducted for the performance of spalling. A spalling model was developed and calibrated with field evaluation data.

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What They Found

A summary of the findings from the field evaluations of punchout, mechanistic analysis of CRCP, development of the CRCP ME design program, sensitivity analysis of the CRCP ME design program, and efforts related to spalling can be summarized as follows:

- There are different types of distresses currently classified as punchouts. Some are caused by structural deficiency of CRCP, whereas some are related to concrete material properties and quality control of construction and materials.
- CRCP sections with non-erodible, stabilized subbase and tied concrete shoulder perform better than CRCP sections that don't have these elements or have only one.
- Load transfer efficiency (LTE) at transverse cracks is maintained at a high level, even when a transverse crack is undergoing punchout distress. With an adequate longitudinal steel amount and subbase support, LTE doesn't seem to play a role in punchout development.
- Mechanistic analysis shows that maximum concrete stresses in CRCP due to wheel loading applications occur at the depth of longitudinal steel, not at the top or bottom of the slab. The effect of subgrade modulus of reaction on the maximum concrete stress at the steel depth is more sensitive than at the top or bottom of the slab.
- Sensitivity analysis shows that the results from TxCRCP-ME are reasonable, even though the sensitivity analysis results will vary depending on the transfer function.
- Spalling can be minimized by better construction practices such as curing.

The limitations of TxCRCP-ME include the following:

- The effect of non-uniformity and erosion of the subbase was not included in this study. However, the effect of these variables – the non-uniformity and erosion of subbase – is indirectly included in the program with the use of a transfer function.
- The inference space for longitudinal steel percentage is quite limited due to the narrow range of longitudinal steel percentage used in CRCP in Texas. To minimize the errors associated with the improper selection of steel percentage, the minimum and maximum steel percentages should be 0.5 % and 0.7 %, respectively.
- The effect of subbase friction on field performance of CRCP was not fully investigated due to the difficulty in estimating actual frictional resistance of old CRCP sections.

What This Means

It appears that a large portion of distresses currently classified as punchout are not actually caused by the structural deficiency of CRCP. It could be that adjustments were made in the past to the slab thickness design to address these distresses, which could have resulted in over-design for slab thickness. As a more accurate transfer function is developed, this inherent conservatism is expected to disappear. The findings of the importance of subbase support on CRCP performance could direct more attention to the slab support design. The mechanistic-empirical CRCP design program developed in this study, TxCRCP-ME, with a transfer function the accuracy of which could be improved with further efforts, could be used for the development of an optimum CRCP system. Improvements in design details and quality control of materials and construction could further improve CRCP performance. The findings on the spalling could be used to minimize spalling distress, thus reducing repair costs. The CRCP 3-D model will require validation using instrumented pavements. The spalling model included in the report will require extensive field validation.

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