Mechanistic Modeling, Validation with Full-scale Load Tests and Structural Design Tables for PICP

Recipient: University of California (Davis) Pavement Research Center

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Project Summary: 6

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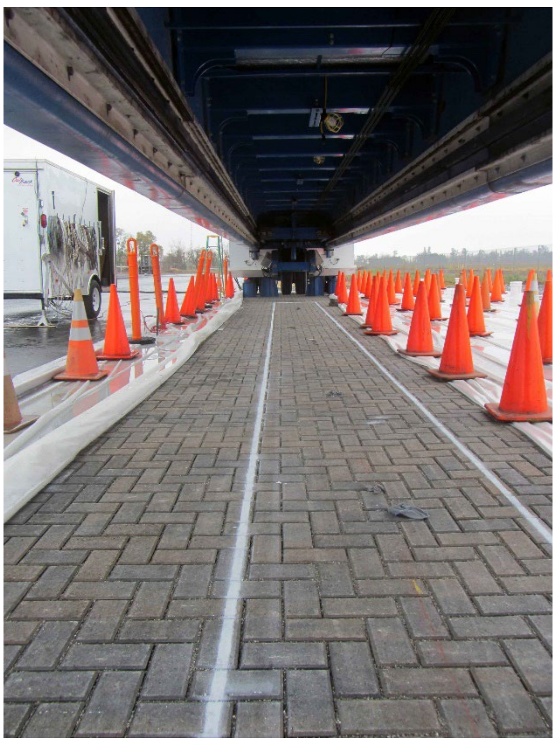
Background and Need

Prior to this research, PICP structural design relied on the flexible pavement design method in the 1993 AASHTO *Guide for Design of Pavement Structures*. While this design method was developed and validated with full-scale testing for impermeable road pavements, it was adapted by ICPI to use for PICP for subbase thickness design tables up to one million 18,000 lb equivalent single axle loads or ESALs. Coincidentally, Caltrans was writing a guide on permeable pavements and this presented an opportunity to include information on PICP structural design.



A Heavy Vehicle Similar applied up to 2.6 million ESALs on PICP section in dry and saturated conditions. The response of the pavement was used to calibrated models to determine the PICP subbase thickness.

Objectives

The UCPRC developed revised design tables for PICP using a mechanistic-empirical design approach. The study included the following:

- A literature review
- Field testing of existing projects and test sections
- Estimation of the effective stiffness of each layer in permeable interlocking concrete pavement structures
- Mechanistic analysis and structural design of a test track incorporating three different subbase thicknesses (low, medium, and higher risk)

- Load tests on the track with a Heavy Vehicle Simulator to collect performance data to validate the design approach using accelerated loading
- Refinement and calibration of the design procedure using the test track data
- Development of a spreadsheet design tool using Open Pave software
- Development of revised subbase thickness design tables using this design tool

Key findings from the mechanistic analysis include:

- Higher applied shear stress to shear strength (stress/strength) ratios at the top of the subgrade, which equate to a higher risk of rutting in the subgrade, require thicker subbase layers, as expected.
- An increase in the stiffness of the surface layer reduces the required subbase layer thickness to achieve the shear stress/strength ratio. However, the effect of the surface layer stiffness on overall pavement performance is not significant due to the relatively low thickness of the pavers (80 mm) and the reduced interlock between them compared to pavers with sand joints.
- For the same shear stress/strength ratio at the top of the subbase, an increase in the stiffness of the subbase layer reduces the required thickness of that subbase layer, especially when the subgrade has a low stiffness.
- For the same shear stress/strength ratio at the top of the subgrade, wet conditions require thicker subbase layers compared to the dry condition, confirming that wet conditions are the most critical condition for design.

The study delivered practitioner-ready subbase thickness design tables based on a specific number of days water stands in the subbase or on a range of days. The tables use a similar format to that currently used in the ICPI Permeable Interlocking Concrete Pavements manual. The minimum design thicknesses required to prevent subgrade rutting in the UCPRC and are less conservative, i.e. thinner subbases especially for semi-arid climates and for high infiltration soils. This can lead to less expensive subbase structures. The complete study is found here.

Outcomes

The subbase thickness design tables developed by the UCPRC were included in the 5th edition of the ICPI manual, Permeable Interlocking Concrete Pavements. The tables also in included in the national design standard, ASCE 68-18 *Permeable Interlocking Concrete Pavement* and in Caltrans Pervious Pavements design guide. The tables are also in an updated version of Permeable Design Pro software program for structural and hydrologic design of PICP. By providing practitioner-ready, validated design tables, designer confidence is greatly increased.

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