PUTTING RESEARCH TO WORK BRIEF

Calibrating M-E Design Software to Wisconsin Concrete Materials

The American Association of State Highway and Transportation Officials is leading a nationwide effort to help state DOTs improve the design of both concrete and asphalt pavements through the new Mechanistic-Empirical Pavement Design Guide. The guide, which includes a written manual and software, was developed to help pavement designers make better-informed decisions and take cost-effective advantage of new materials and features.

The M-E guide combines the use of mathematical engineering principles, laboratory test data and real-world pavement performance to help designers choose the appropriate mixes, pavement thickness, construction parameters and other inputs for the particular traffic demands, expected climate impacts and intended design life of each highway project.

What's the Problem?

The value of the guide's software is most fully realized when it is calibrated for use in a particular geographical area with a library of mechanical properties of typical local materials—aggregates and cementitious materials in the case of concrete pavements. To generate the data required by the software, WisDOT needed to initiate a laboratory investigation of selected concrete properties.

Research Objectives

The objective of this research was to contribute to the calibration of the guide's software by developing a mechanical performance database of Wisconsin-specific construction materials, including a range of aggregates and cementitious materials. These data could then be integrated into the guide as a first step in using it to optimize the designs of concrete pavements made from Wisconsin materials.

Methodology

Using AASHTO test procedures in a laboratory setting, researchers investigated two types of concrete properties:

- Splitting tensile strength, which describes how much "stretching" stress concrete can withstand before breaking.
- Coefficient of thermal expansion, which describes how much concrete tends to expand in size with increases in temperature; small values are generally desirable.

These two properties are critical in designing concrete to optimal thickness, and in the past they have commonly been estimated, or based on other more easily measurable concrete properties (such as compressive strength). However, the guide's software requires measured laboratory values for these properties using local construction materials in order to generate meaningful outputs at the highest level of accuracy. In order to compare actual collected data with traditionally estimated values, researchers also tested the compressive strength of concrete specimens in this investigation.

To reflect a representative selection of Wisconsin-area materials, researchers created concrete samples using several combinations of aggregates collected from around the state. These included glacial gravel, dolomite, quartzite, granite, diabase and basalt. Researchers also varied the levels and types of portland cement and other cementitious materials, such as fly ash and ground granulated blast furnace slag, used in the samples.

Results

As expected, the coefficient of thermal expansion, splitting tensile strength and compressive strength all varied among different cement compositions. A key finding of this study was that the estimated

Investigator

"We made a significant step toward basing concrete pavement design on known values rather than on estimates of unknown accuracy."

–Tarun Naik
University of Wisconsin–Milwaukee
tarun@uwm.edu

Co-investigators:
Yoon-moon Chun and Rudolph N. Kraus

A concrete cylinder is pulled from above and below until it splits, providing critical design data on splitting tensile strength (Fig. 4-2 of the final report).

splitting tensile strength values of the concrete samples tested were inaccurate approximations compared with the actual lab results. The degree of inaccuracy varied among the different concrete mixes. Investigators also found that the amount of thermal expansion varied significantly depending on the mix composition. Differences in the amount of thermal expansion were even seen among similar materials supplied from different geographic regions around Wisconsin.

Benefits and Further Research

The lab results—both in their variance among mixes and in their departure from estimated values—strongly emphasize the importance of this research. Without real input data such as this study generated, the M-E guide will not produce pavement designs that perform as intended. The data collected in this study, while limited in scope, are an important first step in calibrating the M-E guide software for designing concrete pavements in Wisconsin.

As future highway projects using concrete pavement are built with the aid of the software, WisDOT will evaluate the pavement performance and incorporate the resulting data into the guide's data library. This will further improve the calibration of the software and lead to concrete pavements that more accurately reflect designers' intentions and better meet the needs of the traveling public.

The investigators also recommended expanding this research to include an even wider selection of building material sources, which would help complete the design guide's data library and enhance the usefulness of the software across the state.

Project Manager

"An initial library of concrete property data is a necessary starting point for WisDOT to use the Design Guide at its most accurate level in designing concrete pavements."

–Jim Parry
WisDOT Bureau of Technical Services
james.parry@dot.state.wi.us

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James McDonnell, WisDOT Research and Communication Services

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CTC & Associates LLC
ctcandassociates.com