PUTTING RESEARCH TO WORK

BRIEF

Improving Soil Stiffness Estimates for Better M-E Design

WisDOT continues efforts toward implementing the pavement design methodology detailed in AASHTO's Mechanistic-Empirical Pavement Design Guide (MEPDG), which estimates the required thickness of the pavement structure based on local materials properties, climate, and projected traffic levels. Use of the MEDPG represents a significant advancement in technology compared with traditional practices based on AASHTO's 1972 design guide, which relies on layer coefficients derived from only one set of materials and environmental conditions.

Integration of MEPDG into current practice is expected to improve pavement performance from a life-cycle cost perspective because the pavement design will be tailored to meet site-specific in-service distress thresholds. However, implementing this change to WisDOT's pavement design process represents a major undertaking, requiring significant research, training, and policy development.

What's the Problem?

In application of MEPDG to a new project, design engineers require a number of data inputs related to the mechanical properties of the materials that compose the pavement structure. One key parameter is the resilient modulus of the subgrade soil, a value indicating soil stiffness or strength. A previous WHRP research project to establish resilient modulus values for Wisconsin soils provided models needed to estimate the resilient modulus of cohesionless (coarse grained) soils. (WHRP Project 0092-03-11, "Determination of Typical Resilient Modulus Values for Selected Soils in Wisconsin").

This project identified the need for further research to establish resilient modulus values for fine-grained soils (silty and clayey soils) to allow for more complete use of the MEPDG in Wisconsin. These silty and clayey soils typically provide the weakest foundation (subgrade) and present the greatest challenge for designers, making this targeted follow-up research effort particularly important.

Research Objectives

The most accurate way to use the MEPDG is to measure the required input parameters directly (these are referred to as MEPDG Level 1 inputs). For subgrade stiffness, this requires sampling soils from a project site and testing for resilient modulus in the laboratory using the repeated load triaxial standard AASHTO test (AASHTO T307). The time and costs associated with this test make it appropriate only for certain high-volume, high-profile pavement transportation projects.

For other projects, WisDOT designers will likely use estimated (MEPDG Level 2) or representative (MEPDG Level 3) input values for subgrade stiffness.

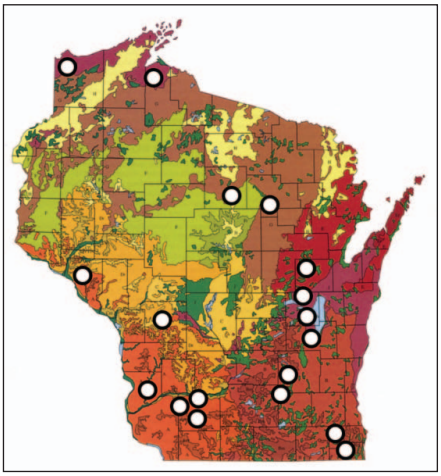
- **Estimated** subgrade resilient modulus values can be closely obtained for a given project by first establishing correlations between resilient modulus and basic soil properties, such as unit weight (density), moisture content, soil plasticity, grain size, specific gravity and other properties. Soil is often tested to determine these basic properties in the course of pavement design. This approach for estimating resilient modulus is less time consuming and less expensive than testing for resilient modulus in the laboratory.
- **Representative**—or average—resilient modulus values are more general MEPDG inputs. An average stiffness value can be established for any type of Wisconsin soil based on its standard AASHTO soil classification. The use of level 3, or representative inputs, results in the lowest design reliability because of the assumption there is a strong relationship between resilient modulus and basic AASHTO classification.

The objective of this project was to establish correlation equations as well as representative resilient modulus values for fine-grained subgrade soils in Wisconsin to facilitate use of estimated (Level 2) design values.

Investigator

"Even if classified identically by AASHTO standards, soils can differ significantly from state to state. This project was instrumental in providing parameters for fine-grained soils in Wisconsin."

— Hani Titi
University of Wisconsin–Milwaukee
hanititi@uwm.edu



Test data from silty and clayey soils across Wisconsin will help build the state's database of soil stiffness values.

Methodology and Results

Researchers analyzed a total of 23 different soils, including AASHTO A-4 soils (silty soils) and A-6, A-7-5 and A-7-6 soils (clayey soils), from around Wisconsin. Together these were intended to represent most of the fine-grained soils likely to be found in the state.

The physical properties of these soils were measured including grain size distribution, plastic limit, liquid limit, specific gravity, maximum dry unit weight and optimum moisture content. The same soils were subjected to the repeated load triaxial laboratory test to measure resilient modulus as specified by AASHTO. To evaluate the effect of density and stiffness, each soil was tested at a range of moisture content levels and dry unit weight levels associated with density below, at and above the optimum moisture content.

Through statistical analysis, mathematical models were developed to correlate soil properties with resilient modulus. Additional analysis helped verify the validity of the correlations. Researchers also established average resilient modulus values, along with a likely range of values within a reasonable confidence level, for each AASHTO soil type.

Benefits and Implementation

The results of this research, together with the findings of companion project 0092-03-11, will serve as a basis for estimating the subgrade stiffness value for the majority of soils encountered in Wisconsin, regardless of the soil type or the degree of design detail (MEPDG Level 2 or Level 3). This will provide pavement designers with the necessary degree of accuracy at a cost-effective price, depending on the appropriate needs for a given transportation project.

As WisDOT moves forward with implementing the MEPDG methodology, the department anticipates using the correlations developed through this research. The department will also likely perform AASHTO repeated load triaxial testing to help verify that the soils studied in this research represent the complete range of fine-grained soils in Wisconsin.

Data collected during construction of pavements designed using the MEPDG could be incorporated into WisDOT's database of material properties and potentially help refine the study's predictive equations. This could provide even more rigorous and reliable values for subgrade resilient modulus for M-E pavement design.

"This research was essential to accurately characterize typical Wisconsin soils and develop resilient modulus correlations and values that can be used in the M-E pavement design methodology."

— Bob Arndorfer
WisDOT Bureau of Technical Services
robert.arndorfer@dot.wi.gov

This brief summarizes Project 0092-08-12, "Determination of Resilient Modulus Values for Typical Plastic Soils in Wisconsin," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

Daniel Yeh, WisDOT Research and Communication Services

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CTC & Associates LLC
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