The Ohio Department of Transportation
Office of Research & Development
Executive Summary Report

Long Term Monitoring of Moisture Under Pavements

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Problem

The research program consisted of three distinct activities. The first activity was a continuation of the monitoring of environmental instrumentation under select pavement sections constructed by the Ohio Department of Transportation (ODOT) in 1995 on US 23 in Delaware County, Ohio. The measurements made by the OSU team at that site consisted of soil moisture, temperature and frost depth profiles. The installation procedures along with the data collected over an eight year period were described in two previous reports

In the second activity, OSU constructed and installed tensiometers to directly measure the pore water pressures in the subsurface soils at seven locations at the DEL23 SHRP test road (four during original road construction and three more in 2002). Those devices were monitored throughout the duration of the current project.

In the third activity, a laboratory testing program was conducted to identify relationships between static soil properties and the design resilient modulus for compacted cohesive subgrade soils. Resilient modulus as well as classification and strength tests were performed on cohesive soil samples. The program to establish the relationships between dynamic soil behavior and static properties is described and a predictive tool developed through the use of artificial neural networks is presented.

Objectives

The state of the moisture regime in the soils immediately beneath a highway pavement slab can influence the behavior and life of a roadway and so should be accounted for in design calculations. Devices installed and monitored at sites across Ohio will provide information necessary to the proper application of effective stress principles in pavement design.

The numerical models being used in the design of pavements are incorporating the response of subsurface materials to changing stress states into the description of the behavior of subgrade soils. Design engineers need a method to estimate dynamic elastic soil properties without performing dynamic laboratory tests for all possible loading conditions. By establishing a relationship (based on extensive testing) between basic soil properties and the dynamic elastic behavior of specific soil types found in Ohio this study will improve the reliability of pavement design procedures.

Description

Pore pressure devices were installed and monitored at several locations in the state of Ohio. A laboratory testing program characterized the engineering properties of a number of natural soils typically found in Ohio. The results of these tests were incorporated into a numerical model to predict the dynamic elastic properties of the tested soils.

Conclusions & Recommendations

Monitoring the environmental instrumentation for the pavements at the LTPP research site began in 1995. Measurement of the volumetric water content continued throughout the study period but repeated failures of the temperature and frost depth sensors limited the usefulness of those data sets. The program to monitor the location of the groundwater under highway pavements was more successful. Most of the sensors installed under pavement sections across Ohio are still functional and indicating high water levels are typical. A model for predicting the resilient modulus from static soil properties was developed for compacted cohesive subgrade soils typical of those found in Ohio. A laboratory program designed to develop a database sufficient to establish relationships between dynamic soil behavior and static properties was conducted. The development of the mathematical model is based on the implementation of artificial neural network algorithms. Neural networks were used because they are flexible and based on mathematical applications without strict statistical boundaries. Once required input parameters and targeted parameters are determined and proper algorithms are set, the algorithms are capable of handling complex problems. Further exploration using different algorithms with improved overall prediction and a better fit to the nature of the problems should be encouraged.
The database could be strengthened with additional test results. Although nearly 800 M_R tests were performed, there are only about 80 soil samples in the database for predicting q_u. In addition, even though our field data show that saturated conditions can be expected in most pavement systems in Ohio, the number of tests performed on saturated samples is not sufficient to provide seasonal M_R values for the ME-PDG model as required. The development of ANNs for soil property prediction with

expediting algorithms capable of handling small data sets should be explored. Another possible approach would be to use artificial neural network algorithms to determine the 3 regression coefficients (k_1, k_2, and k_3) required in the input Level 1 of the ME-PDG model for M_R prediction. The same ANN concept can be applied to aggregated or coarse-grained soils which are key materials for the base layers of pavement structure.

Implementation Potential

Subsurface soil data collected at the Ohio LTPP research site provided environmental information to researchers studying the performance of several pavement designs. The porepressure sensors installed at sites across Ohio have documented the rise over time in groundwater levels under highway sections for a variety of pavement types and field conditions. The recognition that high water levels and saturated conditions are typical under paved sections will impact the design of new and repaired pavements in the state. The numerical method developed to calculate the resilient modulus of cohesive soils for use in pavement design requires only classification and static soil properties as inputs. Comparison of predicted moduli with measured values shows very good agreement even for tests conducted by other agencies on soils with different geologic origins and from different parts of the country. The method presented should replace current procedures estimating the design stiffness for most A-4, A-6 and A-7-6 soils.