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ENHANCEMENT OF FLORIDA HIGHWAYS USING RESULTS FROM AN IMPROVED FIELD PERMEABILITY TEST DEVICE

PROBLEM STATEMENT

Each year the Florida Department of Transportation (FDOT) spends millions of dollars maintaining state roads and highways. Most damage and failure are associated with prolonged exposure to heavy traffic loads and changing environmental conditions, such as temperature fluctuations and precipitation. For example, the amount of rainfall that seeps through the cracks and joints and is retained depends on the permeability of the underlying material. Water that is retained for a significant period can lead to pavement failure. Thus, FDOT has attempted to combat such factors by investing its resources in the development of long lasting pavement systems.

One such effort was research (*WPI# 0510715*, 10/98) that led to the development of a field permeability test device (FPTD), which was designed to measure the permeability of base and sub-base layers beneath pavements using a porous probe. The FPTD can be used to analyze the effect that soils with poor draining characteristics have on pavement performance.

OBJECTIVES

Researchers first explored means for enhancing the safety and ease of use of the FPTD. They subsequently investigated methods to correlate the use of a probe to the permeability. The methods were verified by comparing FPTD test results with American Society of Testing and Materials (ASTM) double ring infiltrometer test results.

FINDINGS AND CONCLUSIONS

Enhancements and Modifications: (*Safety)* Initially, the operator controls were located on the left side of the device, which placed the operator between the device and the adjacent vehicle lane when tests were performed on existing roadways. The control box was thus detached from the device, allowing the operator to place it in the tow vehicle or at any other suitable location. The control box is now connected to the FPTD by two 30-foot long cables.

(*Efficiency)* In the original system, the coring device was positioned at the front of the trailer, with the center ram at the center. When tests were performed over existing pavements, the operator was required to raise and level the trailer prior to coring. After coring, the trailer was lowered and repositioned to align the center ram over the hole. The trailer again had to be raised and leveled before attaching the probe to the ram and performing a test. This process could take almost one hour to complete before any data were collected.

Researchers developed a rotating plate on which both the center ram and coring device stand could rest. As a result, the trailer needed to be raised and leveled only once per test. After coring, the plate is rotated 90 degrees to align the probe over the hole. Setup time went from one hour to twenty minutes.

Another time saving modification was the replacement of the four hydraulic leveling jacks with larger hydraulic jacks that do not require change to their orientation after traveling. The new jacks are simply raised and lowered through the controls, eliminating the need to use the tongue jack during testing.

New pressure transducers were installed on the Mariotte tank and the falling head tube. A laptop computer with data acquisition capabilities was then connected with the existing flow meter and the new pressure transducers. Data are now automatically recorded during a constant or falling head test.

Correlating the Use of a Probe with the Permeability: Researchers investigated three methods that describe the relationship between the flow through a porous probe and the permeability. The first is based on Hvorslev's charts, the second uses the Packer/Lugeon equations, and the third is derived from a finite element computer analysis using Plaxis. All are based on the governing laws of flow through porous media including Darcy's law. The finite element solution was chosen as the benchmark method for future calculations since it was the only one to account for the shape of the probe, which is important because it acts like a boundary affecting the flow pattern, thus affecting permeability. The other methods were based on the same theories but only considered the shape of the porous element.

The finite element solution suggests that an F factor of 12.2 cm be used assuming isotropic conditions. Therefore, the permeability can be calculated from field results using the following formula:

$$k = \frac{q}{12.2*h}$$

where k is the permeability of the soil in cm/sec, q is the exit flow rate in cm^3/sec, and h is the applied head in cm

Verifying Results: Results from the FPTD were compared to results from the ASTM standardized double ring infiltrometer test. The goal was not to produce a precise correlation but to confirm that the device functions properly. Fifteen tests were performed. The test sequence began with a double ring test at a location with consistent soil. Upon completion, the rings were removed and the probe was inserted through the center of the test area. This approach eliminated any influence of variability.

Maximum difference between the methods did not exceed 80 percent, a reasonable range considering that greater differences are not unusual amongst other methods. Permeability has been known to differ by as much as two to three times among results using a single field method in the same soil type.

If results from the device are only compared with each other, then it can produce an accurate assessment of roadbed conditions. Each test result is more valuable as more data become available. The permeability under pavements in poor condition could be compared with permeability under pavements that perform better. Thus, the device is best suited for permeability surveys, for which use a database would prove valuable.

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