Summary of Final Report, BB897
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EXAMINING THE VARIABILITY OF GRANULAR SOIL PERMEABILITY TESTING METHODOLOGY ACROSS FDOT DISTRICTS

PROBLEM STATEMENT

Determining the drainability of the embankment material to be used in a rigid pavement system is of primary concern to the civil engineer. The coefficient of permeability of a soil, along with other geotechnical parameters, provides insight into the long-term performance of the pavement. Thus, the ability to accurately and reliably test for permeability is needed in both the laboratory and the field.

The Florida Department of Transportation (FDOT) employs the standards set forth in the Florida Method for (constant head) permeability of granular soils (FM 1-T 215) for laboratory testing. This standard is identical to the testing methods of the American Society for Testing and Materials (ASTM D 2434-68) and the American Association of State Highway and Transportation Officials (AASHTO T 215-70). These methods employ a rigid-wall, or fixed-wall, permeameter. Assuming the standard preparation and procedure is followed statewide, similar results would be expected from one test location to another, given a standard sample. Unfortunately, similar results have not been occurring.

According to Daniel, et al., fixed-wall cells are subject to a number of drawbacks, the most detrimental of which is imperfect contact between the wall of the cell and the sample, which results in sidewall leakage during the test. As a result, the corresponding permeability values tend to be high. Such results, of course, would fall on the unconservative side of the design envelope, since the actual in-place permeability would probably be lower than tested. In fact, independent tests performed at the University of Texas concerning this matter suggest that the permeability values can vary by at least one order of magnitude due to sidewall leakage. Others cited disadvantages of this type of permeameter, including incomplete saturation due to lack of backpressure, inability to determine the amount of swelling or shrinkage, and lack of control of stresses acting on the soil.

As with other geotechnical laboratory tests, variations can occur in the preparation of the sample and the procedures that are followed. The combination of these disparities along with differences in the testing equipment used for the experimental work can affect the results found in the laboratory. The FDOT has found that variations have been noted in the determination of permeability for granular soils. The inability to accurately and repeatability measure this soil property can lead to incorrect assessments of the drainage ability of a particular material.

OBJECTIVES

The purpose of the work performed in this report was to investigate and examine the variability of granular soil permeability testing methodology across FDOT districts. Specific objectives included the following:

- examination of the variability of current FDOT laboratory procedures
- design and construction of prototype permeameters
- comparison of the prototype permeameters and the current LBR mold
- parametric evaluation of sample preparation and permeability testing
- recommendations for limiting the variability in permeability testing

FINDINGS AND CONCLUSIONS

Researchers investigated the compaction and saturation procedures at three FDOT materials offices, located in Gainesville, Lake City, and Bartow, respectively. They studied permeability results achieved using the test methods employed by each of the offices. In addition, researchers performed a parametric study to investigate the overall effect that sample preparation and testing procedures can have on the resulting coefficient of permeability.

The study shows that both a flexible-wall and grooved rigid-wall cylinder mold reduce the effect of sidewall leakage. On average, lower permeability values resulted when using the prototypes, implying that piping had been reduced. A comparison of the test methods used in the parametric evaluation demonstrated that a thirty-minute (30-min) saturation method with an applied full vacuum and the use of a saturated top porous stone produced the lowest standard deviation between testing trials.

Three permeability mold designs were produced: two flexible-wall molds and one modified rigid-wall mold. The first two were not found to be feasible due to negative design issues. The complexities of the procedure as well as the leakage problems for the flexible-wall permeameter were considered greater problems than the potential benefits that it could offer. The use of seepage rings in Prototype 3 allowed for the continued use of the Limerock Bearing Ratio (LBR) mold with only slight modifications and was considered the best option for reducing the sidewall leakage of the current LBR mold. If the automatic compaction equipment at the laboratory facilities statewide are calibrated and tested, then the use of the current compaction procedures could be continued with greater reliability.

Vacuum saturation had previously been considered difficult due to the inability to maintain sample integrity. Downward saturation and air evacuation of samples can also have an effect on the density and permeability of the soil material, due to a loss of fines through the process. Researchers investigated the effect of fines on permeability and density values (for typical Florida soil), and concluded that a modified saturation method could improve sample saturation.

Increased degrees of saturation have been observed using reduced vacuum pressures of approximately 5-10 inches mercury applied at the top of the sample in the upward direction. A spring is recommended to apply a confining force of 5-10 pounds to the top porous stone and provide a higher degree of sample integrity.

Furthermore, researchers have concluded that, in order to limit the variability seen in permeability results on similar soil samples from different test facilities, a more standardized sample preparation and permeability testing procedure should be pursued.. An example of a proposed sample preparation and permeability testing procedure is provided in Appendix E of the final report.

Please note that the conclusions and recommendations are based on limited testing of only a few types of soil materials. Additional testing will be required to verify the results and to examine the variability in the testing methodology.

BENEFITS

Meeting permeability requirements is critical in the design and construction of concrete pavements, retention areas, and reinforced earth walls. To meet these requirements, engineers need reliable information about the soils that will be used, which requires effective test methods. Consistency in the laboratory results for soil sample testing is required to achieve confidence in the testing methodologies, which are, in turn, necessary to optimize construction. While soils are highly variable, test results from different labs should not produce discrepancies any greater than an order of magnitude of one.

This project resulted in the development of permeameter mold prototypes and an improved testing methodology. These will provide guidance to the laboratories, and so should result in consistent results from one lab to the next. Research results have also been used to update the Florida test method. With better information will come better, longer lasting facilities.

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