Project Summary

Texas Department of Transportation

0-6048: Soil Testing Using Centrifuge Technology

Background

The need to design and construct roadways on highly plastic clays is common in central and eastern Texas, where expansive clays are prevalent. Roadways constructed on highly plastic clay subgrades may be damaged as the result of significant volume changes that occur when such soils undergo cycles of wetting and drying. These volume changes induce vertical movements, accelerate the degradation of pavement materials, and ultimately shorten the service life of the roadway. Proper characterization of expansive clays is required for design of and remediation of roadways on poor subgrade. However, current methods for characterization of expansive clays either do not properly replicate field conditions or require excessive time for testing. An alternative method which better represents field conditions and requires minimal testing involves the infiltration of water into highly plastic clays under an increased gravity field in a centrifuge.

What the Researchers Did

The research team used centrifuge permeameter technology to evaluate the swelling properties of a highly plastic clay. Two centrifuges were used in this feasibility testing program: (1) a smaller conventional centrifuge in which height and weight measurements were taken manually during the testing process, and (2) a larger state-of-the-art centrifuge with the capability of in-flight data acquisition. The basic testing setup in each centrifuge was the same. In preparation for testing, moisture conditioned clay was compacted in a cylinder to the desired density atop a piece of filter paper overlying a porous disc. A second piece of filter paper and a second porous disc were then placed atop the clay specimen. Finally, water was placed on the top of the cylinder overlying the compacted clay specimen and the specimen was flown in the centrifuge. Over a 24-hour period, the clay specimen was allowed to swell. In the smaller centrifuge the initial and the final heights were measured. In the larger centrifuge the height of the specimen was monitored throughout testing.

During initial testing, the rotational velocity of the centrifuge, the height of the specimen, the height of the water, and the testing time were all varied in order to determine what parameters would be best for tests on swelling clays. This testing indicated that a 1 cm specimen of compacted clay, with 2 cm of water ponded above, flown at 200 G for a period of approximately 24 hours yields results that are useful in design. Subsequent testing was used to verify that the test could produce reproducible results.

In order to compare the repeatability and time-savings of centrifuge testing, a series of free-swell tests were conducted. These tests were performed using a range of normal stresses covering those present soil specimens flown in the centrifuge permeameter.

Research Performed by:

Center for Transportation Research (CTR), The University of Texas at Austin

Research Supervisor:
Jorge G. Zornberg, CTR

Researchers:
Jeffrey Kuhn, CTR
Michael Plaisted, CTR

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It was found that a period of approximately 30 days was required before the swelling specimens came to equilibrium. This 30-day period is significant in comparison to the two day time period required in centrifuge testing. A single free-swell test was duplicated in order to evaluate the repeatability of free-swell testing. The repeatability of free-swell testing was found to be on the same order as centrifuge testing.

What They Found

Testing performed for this project has demonstrated the feasibility of measuring the swelling potential of highly plastic clays using a centrifuge permeameter. Tests conducted in the small and large centrifuge were found to be reproducible. Furthermore, testing results from the large and small centrifuge were found to be in excellent agreement.

What This Means

Centrifuge permeameter technology has great potential to provide engineers with a means of quickly and directly attaining the swelling of highly plastic clay. Rather than having to resort to index properties to predict soil swelling, centrifuge permeation of highly plastic clays allows for the direct, prompt, and consistent experimental measurement of swelling. More research is needed to develop practical test procedures for proper characterization of expansive clays.

Above: A Smaller Conventional Centrifuge was Used to Manually Take Height and Weight Measurements During the Testing Process.

Right: A Larger State-of-the-Art Centrifuge, With the Capability of In-Flight Data Acquisition, was Also Used During the Testing Process.

For More Information:

0-6048-1 Characterization of the Swelling Properties of Highly Plastic Clays Using Centrifuge Technology

Research Engineer - German Claros, TxDOT, 512-465-7403
Project Director - Zhiming Si, TxDOT, 512-506-5901
Research Supervisor - Jorge G. Zornberg, CTR, 512-232-3595

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keyword: research

Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-465-7403