TECHNICAL SUMMARY

Investigation of the Applicability of Intrusion Technology to Estimate the Resilient Modulus of Subgrade Soil

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INTRODUCTION

Characterization of base and subgrade soil is essential for the design and analysis of pavement structures. Design of flexible pavements is generally based on static properties such as California Bearing Ratio and soil support value. These properties do not represent the actual response of the pavement layers under traffic loadings. Consequently, the American Association of State Highway and Transportation Official's (AASHTO) guide for the design of pavement structures recommended the use of a resilient modulus (M_r) for characterizing the base and subgrade soil and designing flexible pavements. As a result, the use of resilient modulus by highway transportation agencies is becoming increasingly popular.

The resilient modulus is usually determined from laboratory or field nondestructive test methods. The laboratory procedures are considered laborious, time consuming, and highly expensive. The field nondestructive test procedures have certain limitations with repeatability of test results and the identification of layer properties underlained by soft layers. The shortcomings of these test methods signify the need for an in situ technology that determines the resilient characteristics of subgrade and base soils underneath a pavement.

Among the present in-situ methods, cone penetration testing (CPT) is considered the most frequently used method for charactering geomedia because the CPT method is economical, fast, and provides repeatable and reliable results. The CPT advances a cylindrical rod with a cone tip into the soil and measures the tip resistance and sleeve friction from the intrusion. The resistance parameters are used to classify soil strata and to estimate strength and deformation characteristics of soils such as Young's modulus (E) and shear modulus (G).

This report presents the findings from a pilot investigation to assess the applicability of intrusion technology to estimate the resilient modulus of subgrade soils. Models for predicting soil resilient modulus from cone penetration test parameters, basic soil properties, and soil in-situ stress conditions were developed.

OBJECTIVES

The objective of this study is to assess the applicability of the intrusion technology in estimating the resilient characteristics of subgrade soils.

SCOPE

Field tests using the 2 cm^2 miniature friction cone penetrometer as well as the 15 cm^2 friction cone penetrometer were performed on eight soils which comprise a wide spectrum of Louisiana soils. These soils include cohesive soil (fine-grained) such as silty clay, heavy clay, and overconsolidated clay and cohesionless soil (coarse-grained) such as sand. Repeated load triaxial tests were conducted on undisturbed soil samples obtained from the sites next to the CPT soundings to evaluate their resilient characteristics.

RESEARCH APPROACH

Field and laboratory testing programs were carried out on eight soil types found in Louisiana. Site characterization was conducted using cone penetration tests in which continuous measurements of the cone tip resistance and sleeve friction are recorded. Undisturbed and disturbed soil samples were also obtained from different depths at the investigated sites. Laboratory tests were conducted on soil samples to determine the resilient modulus, strength parameters, physical properties, and compaction characteristics.

The results of the 2 cm^2 miniature friction cone penetrometer were used to develop the correlation between the resilient modulus and the CPT output. For the fine-grained soils (clay, silty clay), the results of the 15 cm^2 friction cone penetrometer were used to calibrate the miniature friction cone in cohesive soils.

CONCLUSIONS

Statistical analyses were conducted on the cone soundings and showed that the results are repeatable at each test site within tolerable deviation. Statistical models for predicting the resilient modulus were developed based on the field and laboratory test results of two soil types and considering two cases of stresses: in-situ conditions and traffic loading. These models correlated the resilient modulus to the cone penetration test parameters, basic soil properties, and in-situ stress conditions of the soil. The models for the cohesive soil were validated by predicting the resilient modulus of the other soils which were not used in the development of these models. Predicted and measured values of the resilient modulus were in good agreement. This research provided a preliminary validation of predicting the resilient modulus of subgrade soils utilizing the cone penetration test.