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Louisiana Transportation Research Center
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Assessment of In Situ Test Technology for Construction Control of Base Courses and Embankments

Introduction

Soil compaction is considered a critical component in the construction of roads, embankments, and foundations. The durability and stability of these structures are related to the achievement of proper soil compaction. Therefore, compaction control of soils is necessary to improve their engineering properties. The current Louisiana state quality acceptance criteria for the construction of geomaterials is based on achieving adequate field density relative to a maximum dry density obtained in the laboratory by using standard or modified Proctor tests. However, the design of these materials is based on engineering parameters such as strength and stiffness. Any project is expected to use a durable material that can perform satisfactorily in the field throughout its expected design life. The missing link between the design process and field quality control makes implementing performance based specifications difficult. Therefore, the construction quality assurance/quality control (Q_A/Q_C) procedures should be based on criteria that closely correlates with the parameters used in the design in an attempt to ensure that the required performance levels are achieved. A fundamental performance parameter for evaluating the constructed highway layers is the elastic modulus of the materials used. Several nondestructive test devices can be used to measure the in situ elastic modulus of the construction materials, including the GeoGauge, the Light Falling Weight Deflectometer (LFWD), and the Dynamic Cone Penetrometer (DCP).

Objective

The main objective of this research is to assess the use of three nondestructive testing devices, the GeoGauge, the LFWD, and the DCP, in order to evaluate the in situ elastic modulus of highway materials for application in the quality assurance/quality control procedures during the construction of pavement layers (base, subbase, and subgrade) and embankments.

Scope

Two well known tests, the plate load test (PLT) and Falling Weight Deflectometer (FWD), were selected to measure the reference elastic modulus values of the tested highway materials needed to correlate the DCP, LFWD, and GeoGauge measurements. The testing program included conducting extensive laboratory and field tests on a wide range of soils under different conditions. The emphasis of this research study was on evaluating the devices, not the materials. Measurements with all devices were taken under the same conditions.

Research Approach

Laboratory and field testing programs were conducted to evaluate the three devices (GeoGauge, LFWD, and DCP) to reliably measure the in situ elastic modulus. The laboratory testing program included constructing different test sections of a variety of geomaterials inside

LTRC Report 389

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two test boxes (5 ft. x 3 ft. x 3 ft.), located at the Geotechnical Engineer Research Laboratory (GERL) of LTRC, and testing using the investigated devices. The testing material included silt clay, clayey soil, cement treated soils, crushed limestone, recycled asphalt pavement, and sand. The field testing program included testing highway sections selected from various projects in Louisiana. In addition, six soil sections and three trench sections were constructed and tested at the LTRC Pavement Research Facility (PRF) site. The laboratory and field tests included the GeoGauge, LFWD, and DCP tests, in conjunction with standard tests such as the PLT and FWD tests. In addition, the California Bearing Ratio (CBR) tests were conducted on the tested laboratory samples and on samples collected from different sections constructed in the field. Statistical regression analyses were conducted on the collected field and laboratory test data to establish correlations between the measurements obtained from the three investigated devices and measurements obtained from the standard tests (PLT, FWD, and CBR). As a result, several good correlations were established.

Conclusions

The results of the statistical analyses showed that there are good correlations between the measurements of the investigated devices and the results of standard tests (FWD, PLT, and CBR) and that these devices can reliably measure the in situ elastic modulus of highway materials. However, amongst these devices, the DCP had the most consistent results within the different tested materials. The correlations obtained from statistical analyses were linear for some models and nonlinear for other models, depending on the test and whether it was conducted in the laboratory or the field. The field test data in general had better correlations to standard test measurements than the laboratory test data. The coefficient of determination (R^2) ranged from 0.81 to 0.95 for field correlations and ranged from 0.36 to 0.9 for laboratory correlations.

The stiffness of a compacted layer is sensitive to the moisture content during compaction, drying of the material, and strength gain with time for cement-treated and lime-treated soils. The current construction procedure requires compaction at the optimum moisture content, ± two percent as obtained from laboratory standard Proctor tests. However, the results of this study indicated that the variation of stiffness within this range was greater than the variation in the dry density.

The results of the laboratory parametric study showed that the GeoGauge influence depth ranged between 7.5 and 8.0 in., while the influence depth of the LFWD ranged between 10.5 and 11.0 in.

Recommendations

One recommendation is to start implementing the stiffness measurements of the investigated devices for mechanistic-emperical pavement design methods while continuing the comparison between the in situ measurements of these devices and measurements by other standard tests in an effort to verify the developed models and to gain further confidence in these findings.

Another recommendation is to start implementing the DCP device for quality acceptance of materials not sensitive to moisture content, particularly stone bases, with an acceptance criterion of PR < 5 mm/blow.

An investigation into the effect of moisture content variation on the elastic modulus measure both by the GeoGauge and LFWD and on the DCP penetration rate is also recommended. The investigation should include laboratory and field tests in an effort to establish moisture/density and strength/stiffness relationships for materials expected to be used for highway construction.