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EVALUATION OF THE PURDUE TDR METHOD FOR SOIL WATER CONTENT AND DENSITY MEASUREMENT

PROBLEM STATEMENT

Time Domain Reflectometry (TDR) is a relatively new technology in the field of geotechnical engineering. Several recent developments have been made regarding the application of TDR to measure in-situ moisture content and density. Recent studies have indicated that the Purdue TDR method—currently approved as the ASTM Standard Method D 6780—may be used in a wide variety of soil types with appropriate soil-specific calibration. Although these new developments are promising, the legitimacy of TDR as a suitable in-situ testing method in the state of Florida is uncertain. An accurate field measurement of density and moisture content is necessary in order to ensure adequate compaction of base, subgrade and embankment materials, to verify that field densities meet FDOT specification requirements. An evaluation of the Purdue TDR Method for typical Florida embankment materials is necessary in order to determine the accuracy of this method compared to the currently utilized nuclear density gauge and other accepted methods.

OBJECTIVES

The primary objective of this project was to evaluate the Purdue TDR method as a reliable and accurate geotechnical testing instrument. Tasks related to this objective include the following:

- performing an extensive literature review to assess recent advances in TDR technology relating to the geotechnical field
- collecting data from FDOT projects to estimate the specific soil calibration constants for typical Florida construction soils
- assessing the sensitivity of the TDR measurement to variation in procedure and calibration constants
- comparing the TDR method to other currently accepted methods
- improving the field testing procedure of the Purdue TDR method in terms of quality and time

FINDINGS AND CONCLUSIONS

Results from testing indicate that the Purdue TDR method is a viable tool for measuring in-situ moisture content. Calibration constant studies indicate that blanket calibration constants can be used for common construction soils in Florida. Thus, in the absence of soil-specific calibration information, a value if 1.00 should be used for soil constant “a” and a value of 8.50 for soil constant “b” for sandy construction soils (A-3, A-1-b and A-2-4 soil). For A-2-4 soils, the percent fines must be below 15%. Sensitivity studies indicate that TDR measurement is not significantly altered by slight deviations in the compaction procedure. TDR calibration results also proved not to be operator dependant, provided that proper procedures and equipment are used. A correlation between the TDR spike driving process and the in-situ LBR tests was developed. TDR water content measurements compared favorably to those taken by the nuclear gauge method. Evaluation of the TDR density measurement was limited, in that no baseline standard was available for in-situ density measurement.

The Purdue TDR method appears to have several advantages over other methods currently used by FDOT:

1. TDR measures both water content and density, virtually simultaneously, on the same soil sample.
2. TDR appears to be as accurate as other current methods for determining field water content.
3. TDR does not require special licensing to operate.
4. The TDR method does not require extensive calibration (the nuclear method does).
5. TDR measurements are available immediately upon test completion.
6. Operator dependency does not contribute significantly to the variability in measurement.

The limitations associated with TDR include the following:

1. The TDR method requires the excavation of soil and is therefore destructive in nature. This results in significant delay, especially in the case of inexperienced operators. Moreover, the destructive aspect of the test makes it necessary to repair the hole resulting from the excavation step.
2. TDR test duration exceeds the duration of comparable methods.
3. The equipment needed to perform TDR testing (i.e., laptop, mold, scale) is more cumbersome to operate than the equipment needed for some other methods.

With additional modifications currently being introduced by the manufacturers to both equipment and procedure, these limitations will be minimized or eliminated.

BENEFITS

This project has provided the FDOT with cutting-edge research on a new technique for in-situ soil measurement. TDR can be implemented as a viable geotechnical testing tool for in-situ soil moisture content. Using the recommended Florida-specific calibration constants, TDR measurement requires no calibration for most applications. The use of TDR for field measurements may be preferable over current methods that use nuclear technology since no safety training or certification is needed. Familiarization with TDR technology will greatly benefit the FDOT as future research is performed. Finding a replacement field test for the nuclear density gauge could create potential savings through the elimination of the extensive calibration and radiation safety program, which is currently needed for the nuclear method since it involves a radioactive source. In addition, the elimination of the nuclear source would also be a significant safety and security improvement for the Department and field operators.

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