INDOT Research

TECHNICAL *Summary*

Technology Transfer and Project Implementation Information

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Final Report

Beta Testing Implementation of the Purdue Time Domain Reflectometry (TDR) Method for Soil Water Content and Density Measurement

Introduction

The main objective of this study was to take the Purdue TDR Method, a new technology for measuring water content and density of soil, to the point where it was widely field tested by users on a broad spectrum of soils. The project accomplished this task by involving researchers at several universities and practitioners in state agencies and in private practice. Results from all these tests were then compared with results from existing technologies and helped to establish a comprehensive database that will serve as the basis for precision and bias statements in the ASTM Standard (D6780) for the method. The project also made improvements to the procedures for performing the test and increased robustness of the equipment based on feedback from the participants.

Accomplishments and Findings

- **Involved Beta Partners**

Six Beta Partners (2 universities, 2 DOTs, and 2 private firms) participated. Several potential Beta Partners expressed interest in joining the program in the near future. Extensive involvement of Beta Partners helped to increase awareness of Purdue TDR research.

- **Updated TDR Testing Device**

TDR testing equipment including electronics were updated based on field evaluation and feedback from Beta Partners. Two cases are currently used in the Beta Test sets. One case contains the TDR probes, molds, digital scale, and tools; the other case contains mostly electronic components. Both cases were designed to make the system more compact and easier to handle in the field.

- **Developed TDR Software**

Software was developed to acquire data from the newly incorporated TDR100 electronics. A robust and accurate algorithm was developed to analyze the TDR signals. Three computer programs were developed in this project to serve different purposes. The reliable and user-friendly software was distributed to Beta Partners for evaluation and was significantly upgraded based on their feedback.

- **Further Developed TDR Testing Theory**

Bulk electrical conductivity contained in the TDR signal was utilized in addition to apparent dielectric constant to develop a theory to simplify the field measurement of soil water content and dry density. The new procedure is called the One-Step Method and it reduced the time required to run the test from around 15 minutes to around 3 minutes. This makes TDR technology more competitive as a reliable tool for compaction quality control.

• **Established Criteria on TDR Testing Accuracy**
From laboratory and field evaluations, the accuracy of water content measurement by TDR falls within ±0.01 of oven-dried results and that of dry density falls in ±3% of values measured by other means.

Explored the Potential Application of TDR on Unconventional Materials
Work in this project showed that TDR can also be a useful tool to characterize various unconventional materials such as fly ash, waste materials, chemically stabilized soils, and concrete. Additional research is needed to explore more fully, the use of TDR for these materials.

Implementation

This project developed hardware and software systems for the application of TDR technology in earthwork compaction quality control. As an important development in this project was a new theory that resulted in simplified TDR field testing procedures. It is called the One Step Method allows field tests to be conducted in about 3 minutes. Results from field evaluation indicted that the One-Step Method is robust and accurate. Detailed procedures for performing field tests can be found in Chapter 8 of this report.

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