Project Summary

Texas Department of Transportation

0-4835: Assessment of Rapid Methods for Density Control of MSE Walls and Embankments

Background

The performance of earth retaining walls and embankments is predominantly controlled by the engineering properties of the backfill. To ensure that the backfill has adequate properties, the soil is compacted to achieve a specified minimum dry unit weight and a water content within a specified range. To assess whether the soil meets the as-compacted backfill criteria, field compaction control is performed by measuring the dry unit weight and water content of the compacted fill. The nuclear gauge is the device most commonly used to make these measurements. However, due to increased regulatory restrictions over devices with a nuclear source, there is an increased effort to find a non-nuclear device to replace the nuclear gauge for compaction control.

What the Researchers Did

A comprehensive literature review was conducted to identify and assess available devices. The identified devices fell into three broad categories: impact methods, electrical methods, and stiffness methods. The *impact methods* relate the impact resistance of the soil with its in situ compactness and include the PANDA dynamic cone penetrometer, the Clegg Impact Hammer, and the standard dynamic cone penetrometer (DCP). The *electrical methods* relate the electrical properties of the soil to its in situ dry unit weight and water content and include the Moisture Density Indicator (MDI), the Electrical Density Gauge (EDG), and the Soil Quality Indicator (SQI). The *stiffness methods* relate the stiffness of the soil to its in situ dry unit weight and include the Portable Seismic Property Analyzer (PSPA), the GeoGauge, and the Soil Compaction Supervisor (SCS). Based on an evaluation of each device, seven of the nine devices (PANDA, Clegg Impact Hammer, DCP, MDI, EDG, SQI, and PSPA) were selected for further study.

The seven devices were evaluated through two field studies and a laboratory study. These studies compared results from the new devices with results from traditional nuclear gauge testing, rubber balloon testing, and oven-drying. *Field Study 1* tested the PANDA, Clegg, DCP, SQI, and PSPA on compacted stockpiles of five different soils. *Field Study 2* tested the MDI and EDG electrical methods at three construction sites in central Texas. The *Laboratory Study* focused on testing the PANDA, Clegg, MDI, and EDG on laboratory test boxes of sand prepared at different compaction levels.

An *additional laboratory study* was performed on compacted clay specimens to assess the relationship between soil stiffness and compaction conditions (dry unit weight, water content). This study was performed because some of the compaction control devices considered in this project measure the stiffness of the soil in an effort to assess its compactness.

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What They Found

Field Study 1 produced data for three impact devices (PANDA, Clegg, and DCP) and one stiffness device (PSPA) on five soils ranging from high plasticity clay to gravel. Data was collected with the SQI, but the required soil-specific calibration was not available and thus the data could not be converted into dry unit weight and water content. None of these devices consistently produced accurate assessments of the compaction level of the soil. Also, none of these devices provides a measure of the water content, and thus each requires an additional means to measure water content if this parameter is specified in the construction specification.

Field Study 2 focused on evaluating two electrical devices (MDI, EDG) at three construction sites in the Austin area. These sites encompassed CH, CL, and sandy clay (CH) soils. The EDG could not be field calibrated and was not used further in this field study. For the clayey soils tested, the values of dry unit weight and water content measured by the MDI did not agree favorably with the values measured by traditional methods.

The *laboratory study* focused on evaluating four of the devices (MDI, EDG, PANDA, and Clegg) on laboratory-compacted specimens of poorly graded sand. The MDI provided accurate measurements of water content, but less accurate values of dry unit weight. The EDG did not provide accurate measurements of either water content or dry unit weight. The Clegg and PANDA only provided qualitative assessments of compaction level, which did not always accurately correspond with the measured level of relative compaction.

The *additional laboratory study* focused on the stiffness of laboratory-compacted clay specimens. The results indicate that the effect of the compaction water content on stiffness is more pronounced than that of dry unit weight for clays.

What This Means

None of the non-nuclear devices examined in this project is currently feasible for replacing the nuclear gauge for field compaction control. Most of the stiffness and impact devices provide a general assessment of compactness, but do not provide the precision required for compaction control. Also, they do not provide a measure of water content, which is a shortcoming when one considers the compaction control of clays. The electrical devices provide measurements of dry unit weight and water content, but their accuracy cannot be confirmed for all soils. However, the MDI and SQI electrical devices are leading candidates to replace the nuclear gauge, if they are improved.

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