Compaction Multimeter

Developing a non-nuclear, multi-purpose measurement tool for Louisiana pavements

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20GTNMSU39

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Tran-SET

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Total Project Cost:

$120,000

The evaluation of compacted unbound aggregate layers is possibly the most common task in transportation projects. The assessment of compaction compliance in engineered fills, subgrades, subbases, and bases in roadways and railways is crucial to ensure durability of ground transportation infrastructure. Often, premature failures in roadways that originate in the unbound aggregate layers can be traced back to inadequate compaction. This is preventable if the problem areas can be identified by a suitable field-test during construction. The most widely used method for compaction assessment in construction is the nuclear density gauge (NDG, seen right) test. There are two main issues with this device: it is radioactive, and it does not completely capture the mechanical performance of unbound aggregates. While the test itself is simple, the cumbersome transportation and servicing of the radioactive device makes the test inefficient. Furthermore, nuclear gauges were designed to extract density and moisture content. These values normal in practice for compaction quality control/quality assurance (QC/QA), but they do not provide the key mechanical properties required in a mechanistic analysis of unbound pavement layers.

Problem Statement

The successful implementation of a non-nuclear, in-situ, mechanical performance evaluation test device requires satisfying the current information needs in a systemwide context. The device must provide reliable density and moisture content measurements to fit within the fixed construction control regulatory framework. A non-nuclear device that measures density and moisture content accurately, rapidly, robustly and that can be as portable as an NDG will encounter doubt due to lack of familiarity by technicians and contractors but would still be the most likely to replace the NDG. However, limiting such device to the determination of these two parameters (i.e., density and moisture content) will not advance the state of the practice in the in-situ mechanical characterization of compacted aggregates. Thus, the development of a transitional device that can measure density, moisture content, strength, and stiffness is vital. By providing side-by-side measurements of all properties, such a device could adapt to the current construction specifications without requiring changes to the business as usual. Inspectors and contractors would have access to real time density and moisture content data in the field, so that they can still be able to use the pass-fail criteria with which they are familiar, and strength and stiffness data can also be recorded and made available to engineers and designers. Over time, the compiled data set could be used to develop progressive modifications to the regulatory framework, effectively phasing out density and moisture content evaluation criteria in favor of mechanical performance standards. The research team hypothesizes that a prototype of a 'compaction multimeter' device can be developed by combining available compatible sensors and technologies. Furthermore, the introduction of redundancy in the measurement (i.e., multiple different sensors measuring the same physical parameter) can substantially enhance the accuracy and robustness of the device.

Objectives

The main objective of this study is to develop a compaction multimeter prototype. This device would be capable of directly measuring the density, water content, strength, and stiffness of a compacted soil, and require minimal material specific calibration.

Intended Implementation of Research

Outreach and Workforce Development: This will be achieved directly by training graduate, undergraduate, and high school students (through camps) interested in pursuing a career in STEM or Transportation Engineering career.

Education: This task supports the federal initiative to build the next generation of transportation professionals to meet the demands of the rapidly changing the 21st-century transportation system. The PI currently supports and mentors five graduate students and three undergraduate students from external grants. The proposed study will help the PI to recruit and train more graduate and undergraduate students in transportation research.

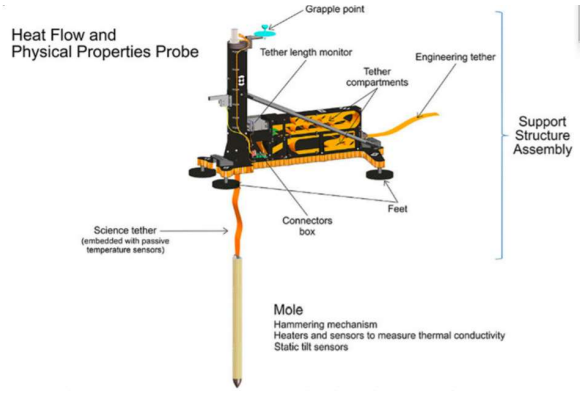

Figure 1: Heat flow and physical properties probe (HP3). NASA Mars InSight Mission https://mars.nasa.gov/insight/spacecraft/instruments/hp3/

Anticipated Impacts/Benefits of Implementation

The main deliverables from this study are:

1) a robust, inexpensive, non-nuclear test for compaction quality control.

2) A final report and implementation report will be prepared and presented at conferences and webinars.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.