In-Situ Mechanical Characterization for Compacted Aggregates

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Evaluating current and emerging in-situ test methods/devices to inform development of an improved automated in-situ testing device

The state-of-the-art in mechanical characterization of soils continues to make significant progress, and the gap with the state-of-thepractice in transportation geotechnics continues to widen. Despite efforts by FHWA and AASHTO to bring practice into the new millennium, it remains almost a half a century behind. New technologies continue to find resistance or serious challenges to adoption. The most exciting advances in real time mechanical response monitoring (intelligent compaction) has been almost entirely driven by the private industry. However, industry has not focused on the development of quality control nor quality assurance devices. The study focuses on this gap and aims to advance the state-of-the-practice by informing the development of future automated in-situ testing devices for the determination of strength and stiffness of subgrade and base pavement layers (with sufficient level of accuracy and practicality).

Problem Statement

The evaluation of compacted unbound aggregate layers is perhaps the most common undertaking in transportation-related projects. The assessment of compaction compliance in engineered fills, subgrades, subbases, and bases in roadways and railways is central to ensure longevity of ground transportation infrastructure. In many cases, premature failures in roadways that originate in the unbound aggregate layers can be traced back to inadequate compaction. These failures are preventable, provided the problem areas can be identified by a suitable field-test during construction.

The most widely used method for compaction assessment during construction is the nuclear gauge density test. There are two primary issues with this device: it is radioactive, and it does not fully capture the mechanical performance of unbound aggregates. While the test itself is simple and robust, the complexity associated with the transportation and servicing of the radioactive device makes the test logistically and economically expensive. Furthermore, nuclear gauges were designed to extract density and moisture content. These parameters are the norm in practice for compaction quality control/quality assurance (QC/QA), but they do not provide key mechanical properties needed for a mechanistic analysis of unbound pavement layers.

There are alternative devices available for field performance assessment; however, they are not necessarily field-friendly. Simple devices (i.e., dynamic cone test and helical probe test - see figure 1), provide only index strengths, and require multiple people to operate, collect, and record data. Since these devices do not produce direct measurements of mechanical properties, the analysis of results often involves the use of physically meaningless correlations, valid only for a narrow range of materials and site conditions.

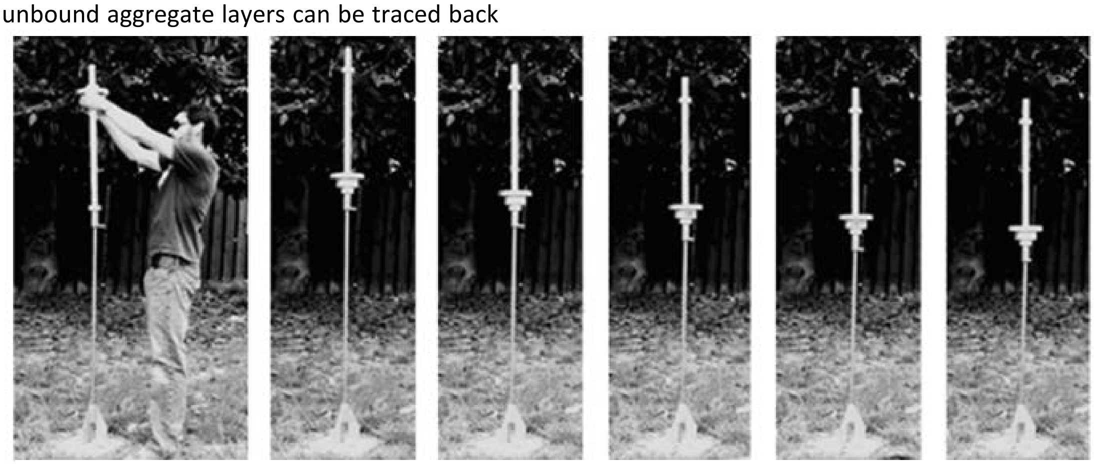

Figure 1. Dynamic cone penetrometer being driven into subgrade.

More sophisticated methods (i.e., surface waves), require complex analysis and data post processing that make them unsuitable for field testing crews or applications that require decision-making in very short time frames such as field compaction.

Summary

The first part of this study has been devoted to cataloguing available technologies for the determination of mechanical properties of compacted unbound aggregates. The research team has sought to critically assess the advantages and limitations of available devices, with the objective of eliminating technologies with inherent limitations. Thus, the remaining subset of technologies should only share operational limitations. The researchers expect to find within this group of technologies a few that could be significantly improved through automation.

Recognizing that successful adoption of new testing equipment depends not only on the technical soundness of the device, the research team has also directly engaged the primary end-users to seek answers to:

What does practice (i.e., state DOTs, contractors) look for in an in-situ test device? What makes the nuclear density gauge so popular, and why no other tests have been as widely adopted by state transportation agencies?

Could available technologies be modified to entice agencies to adopt them? Are the test limitations inherent or simply operational?

Understanding the end-user priorities and engaging New Mexico DOT in the development of rubrics for the evaluation of test methods should help further narrow down the group of test methods to those with the most likelihood of adoption.

Impacts

Improving the in-situ mechanical characterization of compacted unbound aggregates in transportation infrastructure is a basic need in the transition from empirical to mechanistic design. The development and adoption of reliable automated test devices is expected to help engineers optimize their designs while maintaining adequate factors of safety. Furthermore, the same devices would allow highway inspectors and contractors to identify deficiencies in mechanical performance during construction which could prevent premature failure of pavement structures. Findings from this study will serve as the starting point towards the development of mechanical characterization devices in tune with the needs of practitioners and capable of providing the information (properties) required by pavement designers.

Tran-SET

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