JOINT TRANSPORTATION RESEARCH PROGRAM

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Intelligent Compaction of Soils—Data Interpretation and Role in QC/QA Specifications

Introduction

This report describes a study of intelligent compaction (IC) technologies, within the context of actual construction projects, for its potential as a component of INDOT's quality control (QC) and quality assurance (QA) for soils. INDOT identified two projects—U.S. 31 Kokomo and U.S. 50 North Vernon—as projects from which data could be collected to evaluate two IC technologies: compaction meter value (CMV) and machine drive power (MDP). The former is an accelerometer-based IC technology while the latter is energy based. Researchers analyzed correlations between IC values and in situ embankment quality test measures to see how well the IC measures could identify strength as already understood by the in situ measures, especially the dynamic cone penetrometer (DCP) test that INDOT employs for acceptance testing.

Findings

It was established and confirmed for both IC technologies that an averaging of the IC measure ±5 m local to the DCP test location yielded the best correlation results. The correlation between the window-averaged CMV measures and 74 in situ DCP tests from the U.S. 31 project was observed to be quite variable, which discourages the use of CMV as a replacement for the DCP measure that is currently used by INDOT for acceptance of the constructed embankment. A limited head-to-head comparison of CMV and MDP with the in situ measures of DCP, the light weight deflectometer (LWD), and the falling weight deflectometer (FWD) revealed that while the two IC measures had a somewhat strong correlation between them, MDP had a decidedly stronger correlation with each of the in situ measures. However, the correlation between CMV and MDP was somewhat strong, indicating that the two IC measures share strong influencing factors even though they compare differently with the in situ measures. Some factors observed during the study that influenced the relationship are soil moisture and external sources of vibration that add noise to the sensor readings. It is also clearly indicated in the literature that MDP correlates better with DCP on cohesive soils than CMV does, so soil heterogeneity can also be an important factor. Reflection on the collected data revealed a bias in the samples that hindered the Research Team's opportunity to assess well the reliability of CMV for detecting weak areas that would also be evaluated as such by a failing DCP test.

Conducting data collection within the context of real construction projects confirmed that the adoption of IC introduces new challenges for data management. Four particular observations were made:

- It is necessary to establish a data management process that has been tested and corrected for errors.
- IC data might be better utilized during the construction phase by enhancing the in-cab computer display to provide real-time analytical capabilities toward improved quality assurance.
- The enterprise GIS database, a platform that most state highway agencies (SHAs) have, is suited to incorporate IC and associated soil compaction data to support decision-making in the future.

- Users of IC data need ready access to a knowledge resource for the underlying data structure to facilitate any post-analysis using the IC data.

Furthermore, several lessons were learned regarding how to effectively conduct further investigation of IC where data is being collected and analyzed from actual construction projects:

- Data collection and transfer procedures and responsibilities should be formally established, ideally in the pre-construction meeting, and outlined in writing for everyone's reference.
- A single point of contact (not necessarily the Business Owner) should be designated with the authority to issue directives when agreed-upon arrangements for data acquisition and access are not being met.
- The Contractor must guard against any condition that introduces sources of vibration other than the roller drum-soil system.
- Random selection of locations for the in situ DCP tests must be maintained to assess whether an IC measure would agree with the acceptance that would occur based solely on the in situ test and evaluation procedure.
- Personnel conducting the DCP test must be aware to take an accurate dynamic cone penetration index (DCPI) measurement (depth of penetration per blow count) when the soil is hard, so that the measurement is precise.

Implementation

Further investigation of IC application on real projects is needed before INDOT can confidently attach engineering-based meaning to the dimensionless IC measures. However, the technology does hold promise for monitoring the consistency of the soil compaction effort and flagging weak areas in real time during compaction operations. Thus, IC is currently better poised for quality control than for quality assurance, and pilot projects aimed at QC implementation are recommended for the nearer term, while keeping QA implementation as a longer term goal. Specific objectives of further study should include the following:

- To gain further insight on the correlation of the DCP measure with both accelerator-based and energy-based IC measures for various soil characterizations and field moisture conditions,
- To gain a greater sense of the reliability of the IC measures when the embankment strength is low (i.e., confidence in the target value and procedures for setting it), and
- To facilitate broader understanding both within INDOT and among its industry partners of best practices for implementing IC on INDOT projects.

These objectives of further study may be advanced more rapidly through pooled fund studies and the attention of the ICA/INDOT Joint Cooperative Committee.

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