



RESEARCH
SERVICES SECTION

TECHNICAL SUMMARY

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PROJECT COST:

\$125,000



In Field Study 1, researchers used a Caterpillar CS-563 vibratory smooth drum roller to collect machine drive power and compaction meter value measurements.

Field Validation of Intelligent Compaction

What Was the Need?

For a road to perform well over the long term, its subgrade and base layers need to be compacted to provide a stable, uniform foundation for the upper pavement. Intelligent compaction is a promising technology for improving the uniformity and quality of soil compaction: IC allows for real-time measurements of the subgrade and the automatic adjustment of the force of compaction to soil conditions.

Because IC is still a new technology without a long history of use in the United States, several challenges remain before it can be successfully implemented in earthwork construction projects. IC rollers use a proprietary measurement system that has not been fully correlated with in situ devices currently used to measure soil properties in the field, including the nuclear gauge, dynamic cone penetrometer and light weight deflectometer. Also, because IC rollers make continuous measurements, they produce very large amounts of data that can be difficult to manage.

Research was needed to validate IC devices by correlating their measurements with those produced by devices currently used to evaluate soil properties that are related to pavement performance. These properties include resilient modulus, the measure of soil stiffness widely considered to be the best available predictor of pavement performance. Research was also needed in managing the quantities of data produced by IC systems.

What Was Our Goal?

The aim of this research project was to evaluate IC monitoring technology used in earthwork construction for quality control and assurance. Research objectives included:

- Establishing relationships between roller-integrated and in situ compaction measurements, including dry unit weight, DCP index, Clegg impact value and light weight deflectometer modulus
- Characterizing measurement variation observed for the various measurement systems
- Identifying the influences of compaction methods on laboratory moisture-density relationships
- Characterizing laboratory-resilient modulus in terms of soil type, stress state conditions, moisture content and density
- Developing quality control and assurance guidelines for incorporating roller-integrated compaction monitoring technology into soil compaction specifications

What Did We Do?

Researchers conducted three studies using IC rollers at three earthwork construction project sites in Minnesota. These studies compared roller measurement values with on-site measurement of soil dry weight, strength and stiffness using the nuclear gauge, DCP and light weight deflectometer.

- Field Study 1 used in situ devices to verify that IC rollers were capable of identifying areas of weak or poorly compacted soil.
- Field Study 2 established test strips to collect compaction data for a regression analysis correlating in situ and IC measurement values.
- Field Study 3 tested the performance of IC technology as the principal method of quality control for a grading project by documenting calibration procedures and field results, and investigating the relationships between in situ and IC measurement values.

“This project provides the foundation for current efforts to implement intelligent compaction and light weight deflectometers in Minnesota.”

–John Siekmeier,
Mn/DOT Senior Research
Engineer

“This study showed that IC technology has the potential to effectively identify the areas of weak or poorly compacted soil with real-time readings and 100 percent coverage. Statistically significant correlations between measurements were observed for data collected over a wide range of soil characteristics.”

–David White,
Associate Professor, Iowa
State University

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Test rolling on one project verified that a roller-integrated compaction monitoring system could also be used to identify areas of weak or poorly compacted soil.

Researchers also conducted laboratory tests using static, impact, gyratory and vibratory compaction methods to demonstrate different moisture-density relationships for the compaction methods of granular and cohesive soils. They created a geographic information system database for managing the large quantities of data produced by IC rollers and compared it to quality assurance data.

What Did We Learn?

This study showed that IC technology is a feasible alternative for quality control and potentially quality acceptance, but that some challenges remain in interpreting IC roller measurements. There was a statistically significant correlation between different measurements of a relatively wide range of soil characteristics. In addition, soil stiffness tests showed that vibratory and impact compaction methods produce higher resilient modulus measurements than static compaction.

Researchers supplemented these findings by creating a statistical framework for incorporating measurement variations and analyzed field data to develop quality assurance and quality control guidelines for using IC. Recommendations included creating a field inspector's guide and training curriculum, conducting on-site training for inspectors and contractors, educating designers to encourage their participation in establishing quality control criteria for rollers, and facilitating consistency between roller manufacturers.

What's Next?

Phase II of this project, described in the forthcoming Mn/DOT report "Implementation of Intelligent Compaction Performance Based Specifications in Minnesota" (2009-14), further addresses the relationships between IC measurement values and in situ measurement techniques. This phase established the groundwork for statistically grounded IC specifications, an IC training and certification program, and new IC field analysis tools.

This project is part of a larger, ongoing Mn/DOT effort to implement IC technology. An assessment of Mn/DOT's ongoing work in this area was issued in "[Intelligent Compaction Implementation: Research Assessment](#)" (2008-22).

This Technical Summary pertains to Report 2007-10, "Field Validation of Intelligent Compaction Monitoring Technology for Unbound Materials," published March 2007. The full report can be accessed at <http://www.lrrb.org/PDF/200710.pdf>.

The more current reports mentioned above include Report 2009-14, "Implementation of Intelligent Compaction Performance Based Specifications in Minnesota," scheduled for publication May 2009, and Report 2008-22, "Intelligent Compaction Implementation: Research Assessment," published July 2008. The latter can be accessed at <http://www.lrrb.org/PDF/200822.pdf>.