



PUTTING RESEARCH TO WORK

BRIEF

Evaluating Benefits and Limitations of Intelligent Compaction

Construction of high-quality pavements is dependent on achieving adequate density or compaction throughout the supporting soil, base and pavement layers. The objective of achieving a specified density is to ensure a minimum layer stiffness and strength of the upper layers and to reduce the likelihood of detrimental, long-term changes in the properties of the supporting materials. Currently, density is evaluated by either visual inspection (typical for embankments in Wisconsin) or in-place density measurements with nuclear density gauges or other devices.

What's the Problem?

Because of soil variability and other factors, it can be difficult to achieve and measure the desired density during compaction. A technology called intelligent compaction shows promise for improving this process on unbound soil and aggregate materials as well as on in-place asphalt mixtures. IC is called "intelligent" because the compaction rollers are equipped with sensors that measure density on a continuous basis; and an on-board computer collects and displays density measurements for each small section of the site as determined by a Global Positioning System unit. The operator is then able to monitor layer stiffness and adjust compactive effort in real time to achieve uniform and acceptable density across the entire site.

Research Objectives

The goals of this project were to help WisDOT evaluate the advantages and limitations of IC for achieving density, and to determine the material types and conditions that might cause inaccuracies in IC roller output concerning layer stiffness and other properties.

Methodology

Researchers evaluated IC technologies on three projects in Wisconsin, including two for unbound materials and one for HMA. IC rollers were used to evaluate the densification of unbound subgrade, subbase and base materials on WIS 18 west of Jefferson, WIS 80 north of Highland and US 45 near Eden. Specifically, material types included:

- Subgrade: Low (WIS 18) and high (WIS 80) plasticity clays
- Subbase: One lift of silty sand (WIS 18)
- Base layers: Crushed aggregate base course (WIS 18/WIS 80) and recycled asphalt (WIS 80)
- HMA overlay (US 45)

To evaluate the accuracy of IC measurements, researchers compared IC output to the results of various field tests. For the WIS 18 and WIS 80 unbound materials projects, researchers used a dynamic cone penetrometer to measure stiffness and strength, a nuclear gauge to measure density and water content, and a geogauge to measure elasticity. On the US 45 HMA project, researchers evaluated in-place density using a non-nuclear density gauge and portable seismic pavement analyzer. As a measure of uniformity, an infrared camera was used to monitor surface temperatures, variations in which can indicate potential differences in air void content and gradation. Samples were collected from each project for laboratory characterization of physical and mechanical properties to compare to the data output from the IC rollers.

Results

For unbound materials, demonstration projects indicate that IC is an effective technology for contractors to map the stiffness of layers and identify weak areas prior to the placement of subsequent layers. IC rollers can also be used to determine the best rolling patterns and number of passes to achieve a

Investigator



"Intelligent compaction is an effective technology for improving the compaction of unbound materials and can be used by contractors to more efficiently meet WisDOT's compaction requirements."

—Harold L. Von Quintus
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Project Managers



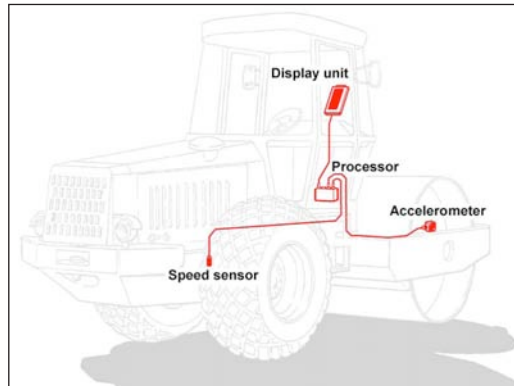
“Intelligent compaction technology has the potential to provide instantaneous feedback on the uniformity and degree of compactive effort on both subgrades and HMA pavements over the entire surface. This would be valuable information for both contractors and WisDOT.”

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Intelligent compaction rollers are equipped with a speed sensor, an accelerometer to measure drum vibration, and a processor that analyzes this data and sends it to a unit that displays a color-coded map of stiffness in the area being compacted.

specific stiffness level in unbound layers, identify when aggregates are being damaged by over-rolling, compact deeper lifts by optimizing compactive effort, and identify locations for point measurements with field devices during construction quality assurance.

However, interpretation of IC data is not a simple process, and IC rollers produce a composite stiffness value that is influenced by both the layer being compacted and its supporting layers. The research recommends that these challenges be addressed through use of control strips and field-test devices in conjunction with IC to develop adjustment factors and to define rolling patterns and roller settings.

Researchers cautioned against the immediate use of IC for HMA because at this point, IC rollers are only used as the breakdown roller; thus further densification of the HMA layer due to compaction by intermediate and finish rollers cannot be captured through use of IC technology. Furthermore, roller response for HMA layers is heavily influenced by supporting layers; as a result, stiffness measurements by IC rollers differ significantly from laboratory tests.

Benefits and Implementation

With further research, IC has the potential to lower construction costs, improve the uniformity of compaction, and increase pavement performance and service life. However, researchers cautioned against requiring contractors to use IC until this technology is more established and uniform equipment output values are established. Rather, IC provides an additional tool that some contractors may utilize to meet WisDOT's compaction requirements in a cost-effective manner. Researchers presented the details of their findings in a Webinar, available at http://www.whrp.org/research-areas/flex/flex_0092-08-07_closeout_webinar.html.

Further Research

More research is needed on the reliability and accuracy of the IC measures, confirmation of improvement in the uniformity of compaction, and quantification of IC's economic benefits. Research is also needed to investigate the effect of lift thickness on IC output and to correlate the IC output from different manufacturers' reporting systems to standard measures of acceptance. WisDOT has no plans in the near future for additional IC pilot projects, but will follow national research on IC as the technology is developed.

This brief summarizes Project 0092-08-07, “Evaluation of Intelligent Compaction Technology for Densification of Roadway Subgrades and Structural Layers,” produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, P.O. Box 7915, Madison, WI 53707.

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