High-Energy Impact Roller Compaction

RESEARCH PROJECT TITLE
Central Iowa Expo Pavement Test Sections: Phase I – Foundation Construction (InTrans Project 12-433)

SPONSORS
Iowa Department of Transportation
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RESEARCH TEAM
David J. White, PhD, PE
Director, Center for Earthworks Engineering Research
Associate Professor
515-294-1463, djwhite@iastate.edu

Pavana K. R. Vennapusa, PhD, PE
Assistant Director, Center for Earthworks Engineering Research
Research Assistant Professor
515-294-2395, pavanv@iastate.edu

Peter Becker
Research Assistant

Christianna White, PhD
Technical Editor

RESEARCH PARTNERS
Iowa Department of Transportation
Central Iowa Expo
Boone County, Iowa Engineer
Foth Engineering Alliance
JB Holland Construction, Inc.
Center for Earthworks Engineering Research

IOWA DOT CONTACT
Mark Dunn, PE
Operations Research Engineer
Office of Research & Analytics
Iowa Department of Transportation
515-239-1447, mark.dunn@dot.iowa.gov

MORE INFORMATION
http://www.ceer.iastate.edu

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The Iowa Department of Transportation (DOT) worked with its research partners to design comparative pavement foundation test sections at the Central Iowa Expo Site in Boone, Iowa. The project was constructed from May through July 2012. Sixteen 700 ft long test sections were constructed on 4.8 miles of roadway with the following goals:

- Construct a test area that will allow long-term performance monitoring
- Develop local experience with new stiffness measurement technologies to assist with near-term implementation
- Increase the range of stabilization technologies to be considered for future pavement foundation design to optimize the pavement system

This tech brief provides an overview of the high-energy impact roller compaction technology and results from a test section that was constructed and tested using this technology on the project.

High-Energy Impact Roller Compaction

Application of high-energy impact roller (IR) compaction technology to earthwork and stabilization projects in Iowa has been limited primarily to concrete pavement recycling projects, but is recently seeing increased interest. IR is essentially a non-circular-shaped, tow-behind solid steel compactor that typically varies in weight from about 9 to 15 tons. The dynamic impact compaction energy is transferred to the soil by means of the lifting and falling motion of the non-circular rotating mass. The type of roller depends on the soil type and moisture regime and depth of treatment needed. The rollers are pulled at relatively high speeds (typically about 6 to 8 mph) to generate a high-impact force that reportedly can densify material to depths greater than 6 ft, which is significantly deeper than conventional static or vibratory rollers (Clegg and Berrangé 1971).

One disadvantage of this technology is that the high-impact forces disturb (i.e., loosen) the top 0.25 to 1.5 ft of the surface so the top layer needs additional compaction with conventional rollers. The vibrations caused by the impact rollers and their effect on nearby structures (e.g., underground utilities/pipe lines or nearby building structures) are important to consider with this technology. Some case studies indicated that the vibration effect is minimal beyond 30 to 45 ft from the impact source (Bouazza and Avalle 2006).

The range of applications of IR is broad and includes the following:

- In situ densification of existing fill, collapsible sands, landfill waste, chemically-stabilized soils, mine haul roads, and bulk earthwork
- Thick lift compaction
- Existing pavement rubblization to create a new subbase
- Construction of water storage and channel banks in the agricultural sector

Description of Test Sections and In Situ Testing

A high-energy impact roller weighing about 19,000 lb (drum weight) was used to rubblize and push down the chip seal coat and the existing granular subbase on the 10th St. North and South segments. The roller is a non-circular-shaped, tow-behind solid steel mold and was pulled using a tractor. The test sections were compacted using 20 roller passes with the high-energy impact roller at a nominal speed of 7 mph (on May 30, 2012), and then compacted using a vibratory smooth drum roller (on June 7, 2012).

The test sections originally consisted of a thin chip seal coat at the surface, about 6 in. of granular subbase classified as SM or A-1-a (14% fines content), and subgrade soil classified as CL or A-6(5).

In situ dynamic cone penetrometer (DCP) tests were conducted at 10 locations along the test section prior to IR passes, after 12 and 20 IR passes, and after vibratory smooth drum roller passes. DCP tests were conducted and California bearing ratio (CBR) profiles were determined in accordance with ASTM D6951.

In Situ Test Results and Observations

DCP-CBR profiles from two selected test locations are shown in Figure 1. Results and field observations indicated that the chip seal coat surface was rubblized as expected. The chip seal coat surface during IR compaction (after 7 passes) is shown in Figure 2.

DCP test results at some locations indicated improvement in CBR with depth, while at other locations showed de-compaction at shallow depths. For example, at Pt(3) in Figure 1, the CBR from about 4 to 6 in. depth increased from an average of about 55 to 77 after 20 IR passes. On the other hand, at Pt(7) in Figure 1, the CBR values at almost all depths were lower after IR passes. Improvement of the underlying subgrade was not expected, as it is not possible under saturated conditions.

Concluding Remarks

In situ test results and observations indicated effective application of high-energy IR to rubblize the surface chip seal coat. Due to the limited scope on this project, potential advantages of the high-energy IR for earthwork compaction warrant additional demonstration. However, this demonstration provided hands-on experience to researchers and practitioners with this technology.

References

Bouazza, A., and D. L. Avalle. 2006. "Verification of the effects of rolling dynamic compaction using a continuous surface wave system." *Australian Geomechanics.* Vol. 41, No. 2, pp. 101-108.

Clegg, B., and A. R. Berrangé. 1971. "The development and testing of an impact roller." *Transactions of the South African Institution of Civil Engineers.* Vol. 13, No. 3, pp. 65-73.

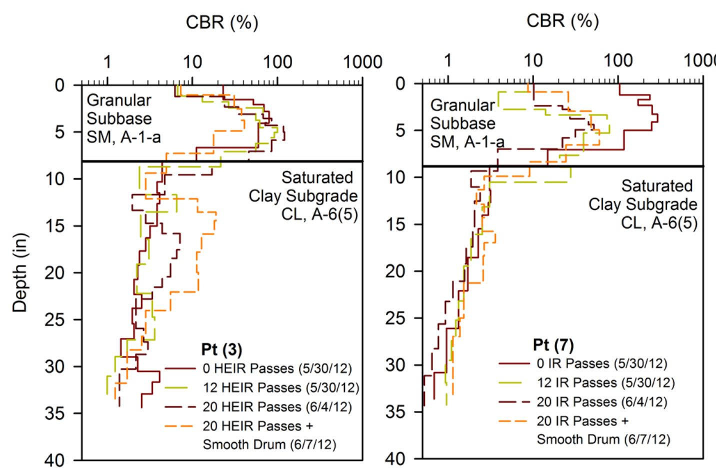

Figure 1. DCP-CBR profiles at two select locations

Figure 2. Chip seal coat surface during high-energy IR (HEIR) compaction