RECLAMATION *Managing Water in the West*

Spring 2014
Research and Development Office
Bulletin 2014-06

The Knowledge Stream

Research Update

Using Intelligent Compaction for Better Earthwork Construction Control

Real-time analysis of compactor drum vibrations and roller position to document compaction

Bottom Line

This research investigates an innovative earthwork construction control technology, intelligent compaction, to determine its benefits for Reclamation over traditional compaction control.

Better, Faster, Cheaper

Intelligent compaction can result in higher quality and more efficient and uniform soil compaction. However, its real benefit lies in documenting 100 percent of the compacted area, which could help avoid costly field investigations if later dam safety issues develop.

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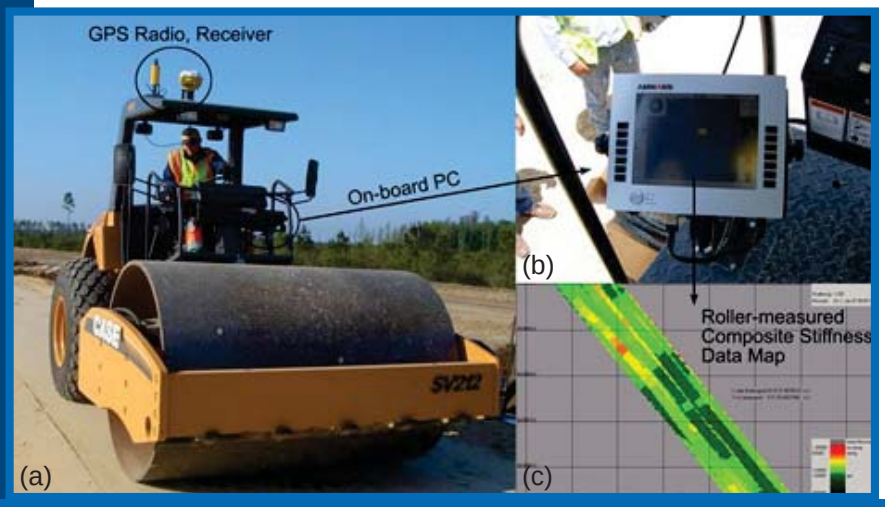
Problem

Soil compaction is the practice of mechanically increasing soil density and is used in numerous applications, including: pipeline embedment, stability berms, canal linings, and embankment fills. Current earthwork tests measure the density in a single location (spot test) and are carried out per a certain volume of fill placed—typically, testing about a half a cubic foot for an area that can contain hundreds or thousands of cubic yards of soil, depending on the nature of material and the placement. This single spot test in a small area is akin to judging the condition of a football field after examining a few blades of grass. The test cannot provide information about the density of the entire area. Thus, if a dam safety issue arises a decade or two later, there are no initial construction data that can illuminate potential problem areas. Instead, to analyze the site, field investigations would need to be conducted, which commonly cost hundreds of thousands of dollars, and could reach millions of dollars on large dams.

Thanks to onboard instrumentation, computing, and the Global Positioning System (GPS), it is now possible to document information about the soil density over the entire site, rather than a single small test spot. With Intelligent Compaction, the state of compaction of soil can be determined in real time and compaction data for quality assurance/quality control (QA/QC) can be documented—for little to no additional cost. By using Intelligent Compaction during construction, these data can be used years later to analyze any future issues without further expensive field investigations.

Intelligent Compaction was primarily developed in the transportation industry, and Reclamation is leading the way in importing this technology into dam safety. In its current form, Intelligent Compaction is available on heavy compaction equipment, but it is anticipated that the technology will become commercially available in smaller equipment (e.g., plate vibrators). This can be implemented in a variety of approaches, including using the Intelligent Compaction roller to:

- Verify adherence to specifications (i.e., track number of passes)
- Determine the over or undercompacted zones for spot testing purposes
- Monitor the compaction curve to establish when a material is fully compacted
- Correlate the roller measured values to traditional spot test values, such as density



Typical Intelligent Compaction equipment, highlighting (a) instrumented roller with vibration sensors and GPS, (b) onboard personal computer, and (c) roller-measured data map.

Solution and Results

This Reclamation Science and Technology Program research project analyzed the practical aspects of using Intelligent Compaction in the Echo Dam Seismic Modification Project. Earthwork specifications mandated that the contractor employ Intelligent Compaction equipped rollers to collect and store these data during compaction operations. Including Intelligent Compaction in the specifications did not increase the construction cost and resulted in documentation of compaction operations throughout the site.

Benefits for Intelligent Compaction include:

- Provides QA/QC data for construction with 100 percent coverage. This is a tremendous improvement over the less than 1 percent coverage for traditional methods and allows inspectors to hone in on problem areas quickly and effectively.
- Decreases dependence on density testing (e.g., using sand cone or nuclear density gage) as the roller becomes the primary QA tool. This eliminates the need for extra personnel and costs associated with density testing. Further, this can be used for materials that are difficult and expensive to test for density, such as pea gravel and rockfill.
- Provides GPS position-indexed and time-stamped QA data for the entire constructed area. These comprehensive electronic data can be stored long-term and referenced if issues arise requiring investigation into the as-built facility.
- Avoids over and undercompaction, which can lead to undesired performance. Real-time data provide immediate feedback for operators to determine where more compaction is needed, for more efficient and uniform compaction operations.
- Allows for the assessment of uniformity of compaction. Uniformity is currently not specified or controlled by Reclamation mainly due to the limited number of spot test data points available. Intelligent Compaction would enable the direct assessment of uniformity.

Intelligent Compaction roller compacting filter sand at Echo Dam. Photograph courtesy of Michael Talbot, Reclamation's Upper Colorado Region.

"Reclamation is posed to greatly benefit from Intelligent Compaction as it provides better coverage, better results, and better documentation than traditional spot-check methods."

Todd Hill
Safety of Dams Project Manager, Reclamation's Mid-Pacific Region

Future Plans

Intelligent Compaction technology should be implemented on a proof-of-concept basis on upcoming Reclamation projects. While Intelligent Compaction could be used in many ways, it is recommended that Reclamation start with the simple approaches to more strictly and easily enforce method specifications and focus spot testing on roller-identified over or undercompacted zones, rather than choosing locations at random. This will provide a higher quality product.

As a next step, it is recommended that Intelligent Compaction be implemented alongside traditional QA/QC for upcoming projects. This work should include the construction of representative test fills. This approach will give Reclamation personnel and contractors experience with the technology, while ensuring that a consistent level of quality is achieved via the traditional QA/QC methods and help develop best practices.

Reclamation should also evaluate the use of Intelligent Compaction for compacting select embedment materials for pipelines, and to document roller compacted concrete placements.

More Information

www.usbr.gov/research/projects/detail.cfm?id=406