LOUISIANA TRANSPORTATION RESEARCH CENTER
LTRC

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Field Evaluation of Roller Integrated Intelligent Compaction Monitoring

INTRODUCTION

Roller Integrated Compaction Monitoring (RICM) refers to the compaction of road materials, including subgrade soils, aggregate bases, stabilized materials, and asphalt-paving materials, using modern rollers equipped with an integrated intelligent compaction (IC) or continuous compaction control (CCC) measuring system.

Compaction with standard rollers is typically through a trial-and-error process and quality control is based on the experience and judgment of individual contractors. On the Department side, standards require contractors to build uniform pavement structure layers, with minimum spacing of 1000 ft. for quality assurance (QA) tests. These selected QA point locations are expected to represent the entire section. In reality, many factors such as variation in soil gradation, soil composition, moisture contents, and subgrade condition affect the homogeneity of the compacted material, resulting in non-uniformity of compaction and hence stiffness.

The intelligent compaction technology continuously records the roller's location and reaction to layer stiffness and plots the result during compaction operations, so the roller operator can adjust roller passes (number and location) to ensure appropriate coverage and compaction effort. The field-generated data and plots are available to the contractor and Department of Transportation. Many purport that the measurements can provide a good means for quality control/quality assurance (QC/QA) of compaction operations.

There was a need to demonstrate and evaluate the emerging technology in real construction projects and its potential implementation logistics (specification, etc.) within Louisiana.

OBJECTIVE

The objectives of the research were to:

1. Demonstrate the value of RICM to accelerate construction, reduce re-work, and improve uniformity of pavement layers.
2. Evaluate the reliability and potential use of RICM data for acceptance and measurements of in-situ stiffness of the constructed earth materials, linking to properties that relate more directly to design (e.g., modulus), and in-service performance.
3. Establish long-term monitoring sections and monitoring protocols/assessments for LTRC to document the impact of implementing these technologies and specification approaches.
4. Demonstrate Strategic Highway Research Program (SHRP) 2 R-07 performance specifications for rapid renewal using non-destructive RICM technology and mechanistic-based in-situ point measurements on a new pavement section including subgrade, stabilized subgrade, base course, and hot-mix asphalt (HMA) layers.

SCOPE

The research focused on shadowing the normal acceptance process, collecting RICM data from each pavement layer as measurement passes (soil) and compaction passes for HMA. Standard specifications and quality assurance acceptance testing governed the project. The research testing supplemented the standard testing conducted by the District 03 testing.

METHODOLOGY

A DOTD road project with multiple construction layers was sought to serve as a demonstration site for both soil and HMA rollers. A specification was developed, finalized, and incorporated into the DOTD road project. The IC rollers were brought to the site and training sessions were held. Data (measurement passes) were collected at the time the soil layers were ready for acceptance, and construction passes were recorded during the asphalt work. Work was coordinated through the LTRC Geotechnical and Asphalt laboratories with District 03 forces and the contractor. The roller data was downloaded and analyzed to compare with other (non-roller based) test results. The research documented the hurdles and strategies associated with the implementation.

CONCLUSIONS

The Project Review Committee (PRC) selected DOTD project 424-04-0053 (H.002890) as the demonstration site, which was located southeast of New Iberia, Louisiana. The project consisted of new frontage roads connecting the existing intersections and frontage roads from Darnall Road to LA 85 along US 90. The typical cross section consists of a 12-in. cement treated subgrade, an 8.5-in. cement stabilized base course, an 2.0-in. asphalt binder, and a 1.5-in. wearing courses—common layers used by DOTD worth testing with the RICM systems. The project is approximately 2 miles in each direction and was initially divided into four sections to evaluate the site, but was further divided into zones (7 to 15, and 20 to 29), based on the contractor and district laboratory sampling and testing plan. Five zones (7, 12, 15, 20, and 29) were selected for closer/closest study.

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LTRC developed the IC specification in conjunction with the project review committee, SHRP2 and NCHRP researchers (including Dr. David White from Iowa State University), and information from intelligentcompaction.com. The IC specifications included a list of qualified roller manufacturers and went through the competitive bidding process. Five contractors bid on the project with a wide range of cost numbers. The item for the soil roller had a range of bids from $15,000 to $95,000. The item for the asphalt roller had a range in bids from $7,000 to $100,000.

The awarded contractor (low-bid process) selected a Caterpillar Machine Drive Power (MDP) roller for the soil measurement passes. The MDP roller selected by the contractor was not the expected choice of roller when the project was designed (an accelerometer based roller was anticipated). The rolling resistance logic differs dramatically from the acceleration-based systems in that when layers were complete and stiff, the single measurement pass had little variation in the MDP values. It did identify some weak areas in Zones 7 and 12, which were subsequently reworked. Utilizing the MDP roller during construction passes (vs. measurement passes), was allowed, but those measurements were not recorded as part of the research. The contractor recognized the benefit of construction passes in the soil layers, but since they were not required, utilization of this capability was unknown. The contractor selected a Sakai roller for the HMA construction passes. This IC roller utilized accelerometer based IC technology, and required different proprietary software. Agreements to use each roller's software existed through the contractor's subcontract relationship with CAT & Sakai, respectively. Analysis software developed by Intelligentcompaction.com (VEDA) was also utilized for analysis.

Developed over recent years, the intelligent compaction (IC) technology has made great strides in combining old and new compaction technologies. Instrumentation, computer technology, and GPS have transformed the slow roller into one of the smartest devices on a jobsite. IC technology, however, is not presumed to be a silver bullet or magic wand, but it can serve the contractor and the state departments of Transportation as a valuable tool. The IC rollers do not adjust soil moisture, so the desired densities and stiffness moduli are still affected by moisture; and similarly, HMA densities and moduli will be affected if the material is outside of the temperature range or mix requirements. Contractor means and methods in these areas are still needed to sculpt a successful project.

The Louisiana demonstration project provided an opportunity to evaluate the various implementation and measurement aspects of the IC technology. The project received a wide range of IC bid prices, which may have been attributed to the initial lack of knowledge and familiarity with IC technology in Louisiana. This project, however, helped improve the knowledge and familiarity of the IC technology through the conduct of the demonstration project, hosting an Intelligent Compaction Showcase at the site, participation in a national webinar, and through other presentations about the research and technology.

There are a multitude of roller manufacturers, each with its own innovative approach, which is great for innovation. However, that can cause difficulties to state departments of Transportation and contractors in implementing the IC technology:

- Because each roller and methodology is different, and the low-bid process exists within government, the selected roller is unknown until the project is let and the preconstruction meeting is held. Over several projects, QA personnel could have different rollers, requiring advanced IT knowledge, mastery of several IC equipment systems, and several software packages (including VEDA). If real-time transfer and analysis and review of data for acceptance is desired, a full-time QA position would likely be required due to vast amounts of data, and to keep up with the contractor's production. From an agency perspective, there appears to be a delicate battle/balance between innovation and standardization. The tough question of "How to standardize the method, results, software, and analysis, without stifling roller innovation?" still exists.

- The contractor would need to consider the purchase/rental of the roller equipment, software costs, and the need for an operator with relatively higher skill and knowledge vs. a standard roller operator. Some contractors may not be ready for the full investment of an IC roller and/or realize the potential benefit in accelerating compaction with IC. Combined with the decision of which roller brand to buy, indecision can heighten, especially since DOTD cannot specify or require a specific brand name roller. An investment into and selection of one manufacturer (over others) could be a tough choice, because it is not known which manufacturer/methodology could eventually wind up on "top."

The ability of the MDP roller to measure without a vibration/accelerometer system has benefits when dealing with Louisiana's wet and weak, clay-based, subgrade soils. The MDP roller was gentle on the soft wet clayey soils by not imparting any unwanted vibration energy into the layer, which could induce pumping or damage to these lower layers of the pavement structure.

Manufacturer equipment and software training/support are critical to the success of an IC project, which includes good communication throughout. In this case, the contractor had relationships with each roller manufacturer, and LTRC was able to interact with roller and manufacturer. Initial setup of roller and GPS connections was a challenge with both project rollers, as LTRC local roller representatives and the contractor were generally learning about the details of the technology for the first time. National roller representatives were helpful, but could not be on site at all times. The contractor's survey staff became proficient in the two systems and needed GPS knowledge and capable, accurate, and reliable GPS equipment, as well as the ability to connect properly and effectively with the rollers' on-board software.

The contractor experienced difficulties with weather, pulverization, and some internal staffing issues, which affected their construction schedule and communication continuities regarding the research. Combining these obstacles with the newness of the IC technology, the contractor cooperated during the project, but did not appear to embrace the new IC technology fully. Follow up conversations with the contractor were unfortunately not reciprocated or possible due to turnover in the contractor's staff.

The contractor can realize some advantages through the utilization of the rollers. Operators can adjust patterns and time based on real-time reactions/display, and the roller display can show and track coverage, passes, and compaction effort (measurement values) hopefully speeding production and assisting with quality control. Weak areas can be visually identified for rework.

Through the use of the IC technology by the contractor, departments of Transportation can also realize some advantages. The rollers' continuous coverage records (vs. point tests at roughly 1000' spacing) can speed construction with contractor's use (appropriate passes/energy). The technology promotes consistent and uniform pavement layers, which can be visually verified. With further research, this technology has the potential to serve as a quality assurance tool, and viable alternative or replacement for the nuclear density gauge. The features of RICM can help improve the construction quality of roadway compaction in Louisiana.

RECOMMENDATIONS

The new technology will hopefully benefit the contracting community the most, as the rollers can speed compaction by focusing efforts where needed to control uniformity. Based on this research experience with the IC rollers and roller-instrumented compaction monitoring (RICM), the researchers have the following recommendations.

- The contracting community should examine and evaluate the benefits of each system, and hopefully utilize a system to increase confidence, consistency, quality, and efficiency in production. It is a valuable contractor tool for Quality Control (QC).
- Initiatives to continue to promote the technology to the contracting community will help spread knowledge regarding these systems and the benefits they offer.
- The specification developed and utilized in this project are not ready for implementation. As experience and contractor demand grow within Louisiana, specifications for implementation of quality assurance and acceptance criteria should be reevaluated.
- Quality assurance (QA) and acceptance by DOTD through the use of these rollers in Louisiana is not readily implementable or recommended at this time.

Possible Next Steps

To further the technology, the Department should consider selecting additional projects (with possible incentives) to utilize intelligent compaction and RICM technologies on the quality control side by the contractor.