Intelligent Compaction— Innovation Description

Intelligent compaction (IC) refers to an improved compaction process using rollers equipped with an integrated measurement system that consists of a highly accurate GPS, accelerometers, onboard computer reporting system, and infrared thermometers for hot mix asphalt and warm mix asphalt (HMA/WMA) feedback control. By integrating measurement, documentation, and control systems, the use of IC rollers allows for real-time monitoring and corrections in the compaction process. IC rollers also maintain a continuous record of color-coded plots that indicate the number of roller passes, compaction level, temperature measurements (for HMA/WMA applications), and the precise location of the roller drum.

The capability of IC technology to improve compaction processes for roadway construction is well documented from projects in Europe, Asia, and the United States. The most significant improvement is in decreasing variability of measured properties. The more uniform material properties obtained by IC technology help ensure higher quality pavements that provide the desired performance and intended service life

Advantages — In addition to reducing the compaction variability of road building materials, these include:

- Optimized labor deployment and construction time: Contractors can roll the material with the right amount of compactive effort on each pass to help ensure that the proper stiffness is achieved. Both under- rolling and over- rolling can lead to poor performance.
- Reduced material variability: IC equipment allows contractors to more closely monitor the stiffness of the material so that there is less variability in the end result. Over the long run, lower variability will result in better pavement performance and reduced maintenance and repair costs.
- Reduced compaction and maintenance requirements: The flexibility to make fewer passes to achieve the correct compaction level minimizes fuel use and equipment wear and tear.
- Identification of non-compactable areas: Areas that fail to reach the target compaction level can be identified as potential areas for reworking the defective material or removing and replacing it.
- Midcourse corrections: Ability to correct compaction problems in a subsurface layer (before additional layers are placed) ensures that subsurface problems do not affect the entire road surface.
- Maintain construction records: IC operation data, with GPS coordinates of compaction can be downloaded to construction quality databases and stored electronically by the contractor for future reference.
- Ability to generate an IC base map: Contractors are able to identify weak spots (typically used in pavement rehabilitation projects such as mill and fill).
- Retrofitting existing equipment: Retrofit kits easily convert most existing rollers to be IC rollers.

Implementation

Equipment Cost: The cost for a new IC-equipped roller for a project is about 3 to 5 percent more than the cost of a conventional roller. The cost of retrofitting an IC integrated measurement system on an existing conventional roller ranges from $50,000 to $75,000, depending on the manufacturer and desired features. These costs are not trivial; however, they can be recuperated within 2 or 3 projects because of the increased efficiency and reduced quantities of rejected material.

Roller operator skills: Some operator and construction supervisor training is required to implement the IC technology. However, the training is not overly complicated or time-consuming and is generally offered by the manufacturer when the equipment is purchased, leased, or rented

Equipment maintenance: The vibration energy associated with vibratory rollers does increase the need for maintenance and calibration of the IC instrumentation; however, the IC instrumentation is robust. The rollers used for IC are basically the same as their conventional counterparts. The primary difference between the IC and conventional equipment is the instrumentation added to identify roller location, measure/control the process, and display and document the level of compaction. With some differences to account for the type of material being compacted, this instrumentation is basically the same for rollers that are designed to compact unbound/ subsurface materials (subgrade soil, subbase, and base) and the pavement surface layers (HMA/WMA binder and wearing courses).

Key Components of instrumentation for both types of material compaction equipment include:

Location referencing: Roller position is established through GPS antenna mounted on the top of the cab.

Measurement: An accelerometer is mounted on the frame of the roller near the roller drum. It collects data on the downward acceleration of the roller frame, which, in turn, is used to determine the downward displacement (deflection) of the roller that results from compaction of the underlying materials.

Processing: The downward displacement, roller amplitude, frequency, and speed information provide a continuous, real-time profile of the level of compaction achieved.

Display: A video monitor in the cab of the roller provides a real time display of the compaction information, including a color-coded map that helps the operator identify the number of passes, stiffness, temperature (HWA/WMA), frequencies, amplitude, and roller speed.

Documentation: The system stores a complete record of the compaction effort electronically. The record can be downloaded at any time for analysis and/or printing. The one additional instrument component found on most IC rollers used for HMA/WMA compaction is an infrared sensor that measures the surface temperature of the HMA/WMA surface. These sensors are mounted on the front and rear of the roller. They are important because they provide a basis for optimizing compactive effort based on the mat temperature. All IC equipment reports the material's level of compaction in terms of a stiffness value rather than density (the standard measure of compaction used in the highway community for quality acceptance). Stiffness is considered a better measure of compaction because it provides a more direct indicator of the material's ability to resist load-associated bending and tensile stresses. A standard method for characterizing the material's stiffness using IC equipment has not yet been established. Consequently, each IC equipment manufacturer has developed its own measure to go along with its particular IC technology. Collectively, these measures are referred to as intelligent compaction measurement values (or ICMVs) and all are considered representative of the in-situ stiffness of the materials and meaningful indicators of the level of compaction.