
Standard Practice for Intelligent Compaction for Embankment and Asphalt Pavement Applications

AASHTO Designation: R 111-22¹

Adopted with Revisions: 2022

Tech Subcommittee: 5c, Quality Assurance and Environmental



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1. SCOPE

- 1.1. This work shall consist of compaction of roadway embankment, or asphalt pavement, or both, using intelligent compaction (IC) rollers within the limits of the work described in the plans or provisions.
 - 1.2. IC is defined as a process that uses rollers equipped with a measurement-documentation system that automatically records compaction parameters (e.g., spatial location, stiffness, temperature, pass count, vibration amplitude, and frequency) in real-time during the compaction process. IC rollers equipped with accelerometers use roller vibration measurements to assess mechanistic material properties and to ensure that optimum compaction and uniformity is achieved through continuous monitoring of operations.
 - 1.3. The contractor shall supply sufficient numbers of rollers, and other associated equipment, necessary to complete the compaction requirements for the specific materials.
 - 1.4. This specification is to be applied during the contractor's quality control.
 - 1.5. All tasks are the contractor's responsibility, unless designated otherwise within this provision.
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2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
 - M 146, Terms Relating to Subgrade, Soil–Aggregate, and Fill Materials
 - MP 39, File Format of Intelligent Compaction Data
 - PP 114, Data Lot Names for Intelligent Construction Technologies
 - R 110, Continuous Thermal Profile of Asphalt Mixture Construction
- 2.2. *Other Documents:*
 - Christopher, B. R., C. Schwartz, and R. Boudreau. *Geotechnical Aspects of Pavements: Reference Manual/Participant Workbook*. FHWA-NHI Course Number 132040, FHWA NHI-05-037. U.S. Agency of Transportation, Federal Highway Administration, U.S. Department of Transportation, May 2006.

- Mooney, M. A., R. V. Rinehart, N. W. Facas, O. M. Musimbi, D. J. White, and Pavana K. R. Vennapusa. *National Cooperative Highway Research Report 676: Intelligent Soil Compaction Systems*. Transportation Research Board, Washington, DC, 2010.

2.3. *Software:*

- Veta Data Management and Analysis Software. Available from <https://www.intelligentconstruction.com/veta>

3. TERMINOLOGY

3.1. *Definitions:*

3.1.1. *cloud*—a Web-based user interface.

3.1.1.1. *cloud storage*—network storage (typically the Internet) where the IC data are stored in virtualized pools of storage.

3.1.1.2. *cloud computing*—the use of computing resources (hardware and software) that are delivered as a service over a network to enable near-real-time visualization (maps) and manipulation of IC data.

3.1.2. *control points* (sometimes referred to as “survey marks,” “survey markers,” “monuments,” “hubs,” or “control points”)—objects placed to mark key survey points on the earth’s surface. These markers are used to indicate elevation and horizontal position.

3.1.3. *coordinate system*—a system that uses one or more numbers or coordinates to uniquely determine the position of a point or other geometric element on a manifold such as Euclidean space.

3.1.3.1. *geodetic coordinates*—a non-earth-centric coordinate system used to describe a position in longitude, latitude, and altitude above the imaginary ellipsoid surface based on a specific geodetic datum. WGS84 and NAD83 datum are required for use with Universal Transverse Mercator (UTM) and State Plane, respectively.

3.1.3.2. *state plane coordinates*—a set of 126 geographic zones or coordinate systems designed for specific regions of the United States. Each state contains one or more state plane zones, the boundaries of which usually follow county lines. There are 110 zones in the continental United States, with 10 more in Alaska, 5 in Hawaii, and 1 for Puerto Rico and the U.S. Virgin Islands. The system is widely used for geographic data by state and local governments because it uses a Cartesian coordinate system to specify locations rather than a spherical coordinate system. By ignoring the curvature of the earth, “plane surveying” methods can be used, speeding up and simplifying calculations. Additionally, the system is highly accurate within each zone (error less than 1:10,000). Outside a specific state plane zone, accuracy rapidly declines, thus the system is not useful for regional or national mapping. The current state plane coordinates are based on NAD83. Issues may arise when a project crosses state plane boundaries.

3.1.3.3. *Universal Transverse Mercator (UTM)*—a metric-based, geographic coordinate system that uses a 2-dimensional (2D) Cartesian coordinate system to give locations on the surface of the earth. This system divides the earth between 80°S and 84°N latitude into 60 zones, each a six-degree band of longitude width, and uses a secant Transverse Mercator projection in each zone (the scale is reduced so that the cylinder slices through the model globe). Zone 1 covers longitude 180° to 174°W; zone numbering increases eastward to zone 60° that covers longitude 174° to 180°E.



Figure 1—Image of UTM Zones in the United States

- 3.1.4. *Coordinated Universal Time (UTC)*—the primary time standard by which the world regulates time. It is one of several closely related successors to Greenwich Mean Time (GMT). For most purposes, UTC is synonymous with GMT. It is based on a 24-hr time scale from the mean solar time at the earth's prime meridian (0° longitude) located near Greenwich, England.
- 3.1.5. *data*—measurements recorded by the instrumented roller, or information generated/processed from these measurements (e.g., GNSS coordinates, stiffness, temperature, pass count, speed, frequency, amplitude).
- 3.1.5.1. *gridded all passes data*—includes all measurement passes recorded for a given grid (see Figure 2). This data is generally used to build compaction curves for establishment of rolling patterns.

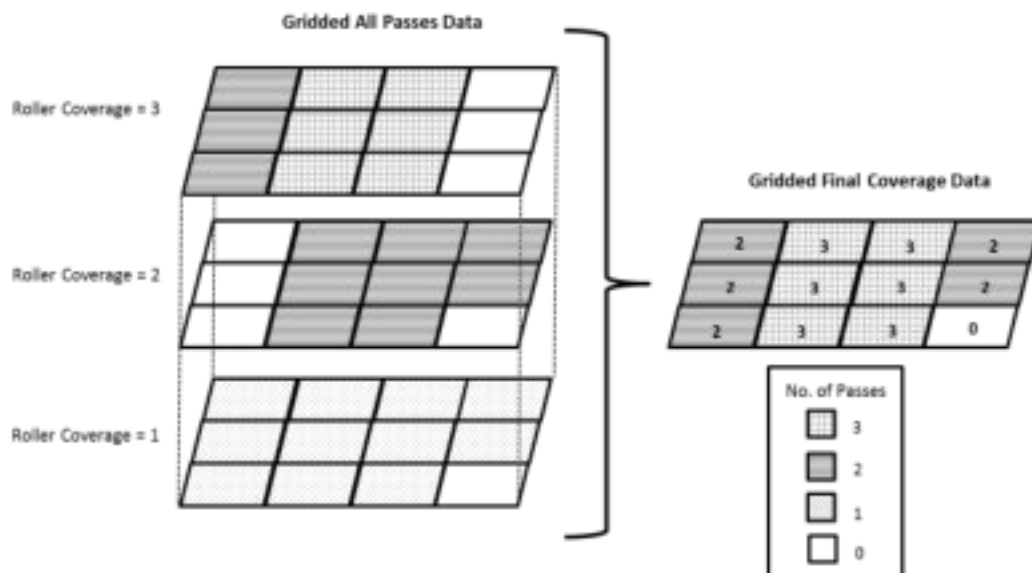


Figure 2—Schematic of Coverage, Gridded All Passes Data, and Gridded Final Coverage Data

- 3.1.5.2. *gridded data*—data processed from the raw data using meshes. The raw data is duplicated over the meshes for the entire roller drum width, resulting in multiple data points covering the drum width (see Figure 3). This process is used to track partial drum overlaps among passes.

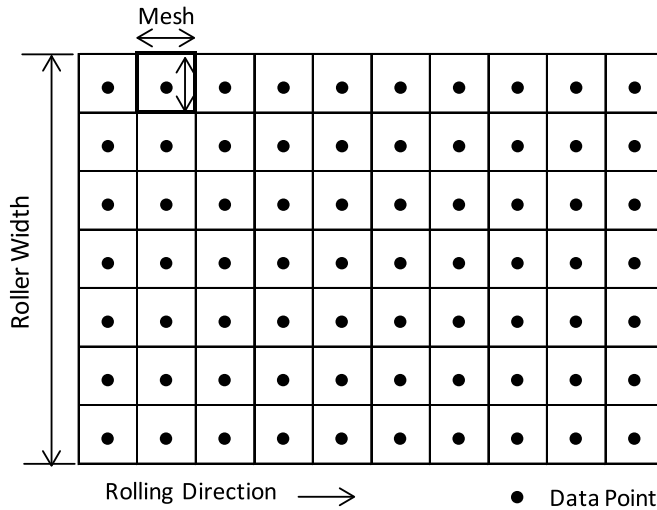


Figure 3—Schematic of Gridded IC Data

- 3.1.5.3. *gridded final coverage data*—summarizes the final (last) measurement passes recorded for a given grid (e.g., total pass count, last stiffness, last temperature [see Figure 2]). Grid sizes are typically at a mesh size of 1 ft (0.3 m) in the X and Y direction for post-processed data.
- 3.1.5.4. *mesh*—a collection of vertices connected to other vertices that defines the shape of the roller drum in 2D polygons (typically multiple squares). The defined data mesh size is generally 0.3 m by 0.3 m (1 ft by 1 ft) in horizontal directions (see Figure 3).
- 3.1.5.5. *raw data*—data recorded during compaction operations prior to the gridding process. It consists of one data point for a roller drum width, recorded at approximately 10 Hz or 0.3 m (1 ft) intervals. Therefore, the data mesh (data footprint) is about one drum width by 0.3 m (1 ft) (see Figure 4).

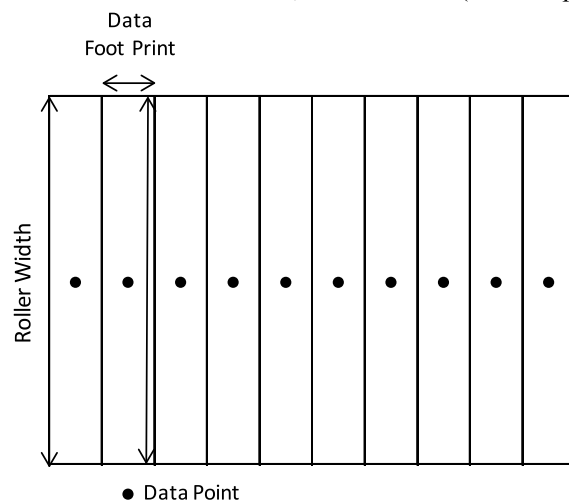


Figure 4—Schematic of Raw Data

- 3.1.6. *Veta*—standardized intelligent construction data management (ICDM) software that stores, maps and analyzes geospatial data resulting from intelligent construction technology (ICT) such as intelligent compaction, thermal profiling and spot test data (e.g., density, moisture). This software can perform standardized data processing, analysis and reporting to provide project summary results from various ICT manufacturers. In particular, the software can provide statistics, histograms, correlations for these measurements, document coverage area and evaluates the uniformity of the ICT measurements as part of the project quality control operations. (Software can be downloaded; see Section 2.3.)
- 3.1.7. *design files*—databases containing the vector image data of the roadway alignment. Design files can be exported from software programs in various formats (e.g., DWG, KMZ, XML).
- 3.1.7.1. *DGN files*—are MicroStation Design Files. These files contain a database of 2D or 3D drawings containing vector image data of the alignment created with MicroStation.
- 3.1.7.2. *DWG files*—are AutoCAD Drawing Database files. These files contain a database of 2D or 3D drawings containing vector image data of the alignment created with AutoCAD.
- 3.1.7.3. *XML files*—extensible markup language data files that use tags to define objects and object attributes; they are formatted much like an HTML document, but use custom tags to define objects and the data within each object. These files are formatted as a text-based database and, therefore, can be edited by a basic text editor.
- 3.1.8. *global navigation satellite System (GNSS)*—a satellite system that is used to pinpoint the geographic location of a user’s receiver anywhere in the world. Three GNSS systems are currently in operation: the United States’ Global Positioning System (GPS), the Russian Federation’s Global Orbiting Navigation Satellite System (GLONASS), and Europe’s Galileo. Each of the GNSS systems employs a constellation of orbiting satellites working in conjunction with a network of ground stations.
- 3.1.8.1. *global positioning system (GPS)*—a space-based satellite navigation system that provides location and time information anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. This system also provides the time stamp needed for IC.
- 3.1.8.2. *GPS base station*—a GPS receiver at an accurately known fixed location that is used to derive correction information for nearby portable GPS receivers. This correction data allows propagation and other effects to be corrected out of the position data obtained by the portable GPS receivers, which provides increased location precision and accuracy over the results obtained by uncorrected GPS receivers. This system consists of an antenna, radio, radio antenna, and power source. The radio and environment/physical conditions control the distance that the correction signal travels. The typical range of the correction signal is about 3.2 km (2 mi) in radius without repeaters. A repeater may extend the distance an additional 3.2 km (2 mi).
- 3.1.8.3. *real time kinematic (RTK)*—RTK satellite navigation is a technique used to enhance the precision of the ground-based data derived from satellite-based positioning systems (e.g., GPS, GLONASS, Galileo). It uses measurements of the signal’s carrier wave and relies on a single reference station to provide real-time corrections that that can be within centimeter-level accuracy.
- 3.1.8.4. *RTK network*—a system that uses multiple base stations to provide high-accuracy GPS positioning within a coverage area that is generally larger than that covered by a ground-based GPS Base Station.
- 3.1.8.5. *remotely operated video enhanced receiver (Rover)*—a portable radio/receiver used to determine GPS coordinates for given point locations.