ODOT Provisional TM 774

Provisional Method of Test for

INTELLIGENT COMPACTION METHOD

1. SCOPE

1.1 This work consists of using the Intelligent Compaction (IC) Method to continually monitor compaction efforts during asphalt paving operations.

2. REFERENCED DOCUMENTS

2.1 AASHTO PP 81-14
2.2 ODOT TM 773(17)

3. TERMINOLOGY

3.1 **Cloud** - a Web-based user interface

3.2 **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 intelligent compaction data.

3.3 **Cloud Storage** - network storage (typically the Internet) where the intelligent compaction data are stored in virtualized pools of storage.

3.4 **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.

3.5 **Cumulative Measurement Pass Count** - The Gridded Final Coverage Data for pass count (the number of passes). The pass count reflects the number of roller passes in one area of the mat (e.g., 0.3 m by 0.3 m [1 ft by 1 ft area]), not the total number of passes across the width of the mat for a given roller.

3.6 **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.

3.7 **Gridded All Passes Data** - Includes all **measurement passes** recorded for a given grid.

3.8 **Gridded Data** - Data processed from the raw data using **Meshes**. For the intelligent compaction method, 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 2.2). This process is used to track partial drum overlaps among passes.

3.9 **Gridded Final Coverage Data** - Data that summarizes the final (last) **measurement pass** recorded for a given grid (e.g., total pass count, last stiffness, last temperature). Grid sizes at a maximum mesh size of 12.0 in by 12.0 in.

3.10 **Index** - measure or standard to quantify the uniformity of a hot- or warm-mix asphalt construction operation.

3.11 **Intelligent Compaction** - Compaction efforts completed using an **Instrumented Roller.**

3.12 **Instrumented Roller** - A self-propelled roller integrated with a global position monitoring system and onboard documentation system that can display real-time color-coded maps of roller location, number of passes, roller speeds, and amplitude and vibration frequencies of the roller drum. Some systems are also equipped with drum vibration instrumentation, infrared temperature sensors, and/or Automatic Feedback Control. The onboard documentation system on these rollers would also display real-time color-coded maps of stiffness response or pavement surface temperatures, or both.

3.13 **Layer** - The total thickness of each material type. It may be comprised of single or multiple lifts.

3.14 **Lift** - A unit of **material** within a layer that is placed for compaction.

3.15 **Lot** - A new lot is established for each Traffic Lane, each Lift and each shift (maximum of 24 hours).

3.16 **Lot Roller Coverage (LRC)** - The percent of **Roller Coverage (RC)** for the given lot.

3.17 **Mesh** - A collection of vertices connected to other vertices that defines the shape of the measurement area (e.g., roller drum in two (2) Dimensional (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.

3.18 **Measurement Pass** - A roller pass, performed by an instrumented roller, where all required information is recorded in a data file.

3.19 **Real Time Kinematics (RTK)** - A technique based on the use of carrier measurements and the transmission of corrections from the base station, whose location is well known, to the rover, so that the main errors that drive the stand-alone positioning cancel out. A RTK base station requires a real time communication channel for connecting base and rover.

3.20 **Roller Coverage (RC)** - The percent of required compaction area where the minimum required Cumulative Measurement Pass Count for each IC Roller is achieved for each **Lot**.

3.21 **Total Roller Coverage (TRC)** - The weighted, cumulative Roller Coverage for all IC Rollers for each **Lot**.

3.22 **Veta** - A standardized intelligent construction data management (ICDM) software that stores, maps and analyzes geospatial data resulting from 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 quickly in the field from various intelligent compaction and thermal profiling manufacturers. In particular, the software can provide statistics, histograms, correlations for these measurements, document coverage area and evaluate the uniformity of compaction and surface temperature measurements as part of the Project quality control operations. (**Veta** Software can be downloaded from www.intelligentcompaction.com)

4. EQUIPMENT

4.1 Intelligent Compaction (IC) Equipment

4.1.1 **GNSS Antenna and RTK Receiver unit** - Equip Instrumented Rollers with GNSS antenna and RTK receiver units to monitor the equipment locations and track the number of roller passes, meeting the GNSS System requirements per subsection 4.2.

4.1.2 **Temperature Measurement** - Equip each Instrumented Roller with two non-contact temperature sensors, one or near the front of the roller for measuring pavement surface temperatures and a second temperature sensor mounted on or near the rear of the roller. Data will be collected from the temperature sensor on the lead drum in the direction of travel.

4.1.3 **Accelerometers -** Equip each Instrumented Roller that has a vibratory mode with accelerometers mounted in or about the drum to determine the use, frequency, and amplitude of vibratory mode. This will also measure the interactions between the rollers and compacted materials.

4.1.4 **Integrated On-Board Documentation System** - Equip Instrumented Rollers with an on-board documentation system capable of displaying real-time color-coded maps, location of the roller, number of roller passes, pavement surface temperatures, roller speeds, vibration frequencies, and amplitudes of roller drums. Transfer data from the display unit by means of a USB port or cloud storage. Data files shall be compatible with IC data analysis software, Veta Version 4.3 or later.

4.1.5 **Cloud storage and cloud computing** - Provide account access for no less than 3 ODOT users to the real-time monitoring, cloud storage, and cloud computing (i.e. user ID and password) at the pre pave meeting. Continue access to the cloud storage and cloud computing until ninety (90) days after Final Second Notification.

4.2 GNSS SYSTEM

4.2.1 Provide GNSS receivers that are capable of recording an RTK solution with a horizontal tolerance of 3.0 inches. Record the GNSS data using the project

coordinates or as otherwise directed by the Engineer. Use the same coordinate system for all rollers on the entire project and make use of the same reference system. Provide one hand-held GNSS receiver (Rover) meeting the above requirements.

4.2.2 Provide GNSS data in the following format:

- Time: Military, local time zone, hhmmss.ss
- Latitude/Longitude, degrees/minutes ddmm.mmmmmmmm or decimal degrees dd.dddddddd

  or
- Oregon State Plane/OCRS, Northing/Easting nnnnnnn.nnnn, eeeeee.eeee
- Measurement Unit: International Feet
- Grid: Feet, 0.01 ft

5. QUALITY CONTROL, DATA COLLECTION, AND SUBMITTALS

5.1 Quality Control of Rolling Operations - In addition to other QC requirements, perform the following:

- Conduct a daily GNSS check test of the GNSS equipment and rover.
- Ensure target number of passes are set to the applicable Control Strip passes for each IC Roller, or per documented rolling pattern change (ODOT acknowledged).
- Verify daily that pavement temperature readings are accurate to within ± 3°F or ± 1.5% of reading, whichever is greater.
- Download and analyze the data from each active roller on a daily basis per Section 00745.49-a-4.

5.2 GNSS Setup - Prior to the start of ACP delivery for the shift, ensure that the equipment is set up and operating properly using the following procedure:

- Verify that the IC roller(s) and rover(s) can receive an RTK corrector throughout the project limits.
- Begin ACP placing only after obtaining proper GNSS verification. IC vendor's recommended verification process may be used to augment the following procedure. Move the IC roller around until the GNSS header computation is initialized. Move the IC roller and park at a selected location. Record the GNSS measurements from the IC roller ensuring the distance offsets are applied so that the GNSS coordinate is at the center or at left/right edges of the front drum. Mark two locations on the ground adjacent to the right and left edges of the front drum contact patch. Move the IC roller from the marked locations. Use a hand-held rover to measure coordinates at the marked locations. Average the rover GNSS measurements if the roller GNSS measurement is at the center of the front drum. The differences between the roller GNSS and rover measurements shall be within 6 inches for northing and easting. (see AASHTO PP81-14)

5.3 IC Documentation - At a minimum, provide to the Engineer the Intelligent Compaction information and data elements shown in the tables below in either ASCII or text format in an electronically recorded data file for post processing for each Lot:

Intelligent Compaction Data Information

TABLE 774-1

Item No.	Description
1	Section Title
2	Machine Manufacture
3	Machine Type
4	Machine Model
5	Drum Width (ft)
6	Drum Diameter (ft)
7	Machine Weight (ton)
8	UTM Zone
9	Offset to UTC (hrs)
10	Number of IC data points

Intelligent Compaction Data Elements

TABLE 774-2

Item No.	Date Field Name	Example of Data
1	Date Stamp (YYYYMMDD)	e.g. 20080701
2	Time Stamp (HHMMSS.SS - military format)	e.g. 090504.00 (9 hr 5 min. 4.00 s.)
3	Longitude (decimal degrees)	e.g. 94.85920403
4	Latitude (decimal degrees)	e.g. 45.22777335
5	Easting (ft)	e.g. 354048.300
6	Northing (ft)	e.g. 5009934.900
7	Height (ft)	e.g. 339.9450
8	Roller pass number	e.g. 2
9	Direction index	e.g., 1 forward, 2 reverse
10	Roller speed (mph)	e.g. 4.0
11	Vibration on	e.g., 1 for yes, 2 for no
12	Frequency (vpm)	e.g. 3500.0
13	Amplitude (in.)	e.g. 0.6
14	Surface temperature (^{o}F) -	e.g. 120

GNSS Rover Data Elements: Use the GNSS rover to obtain coordinates for the following locations during daily production:

Boundaries of daily production and exclusion areas

- 4 corner locations per continuous paving panel

- Report data in the following spreadsheet format:

TABLE 774-3

Description	Easting	Northing
Boundary	599078.6875	106230.7813
Boundary	599090.2500	106230.1563
Boundary	599670.5625	100388.3516
Boundary	599682.8125	100388.4219

Density Test Locations

- Each Quality Control and Quality Assurance density test location.
- Identify each location as quality control or quality assurance
- Identify each location with the sublot test ID
- Include Quality Control density test value in reporting
- Report data in the following spreadsheet format:

TABLE 774-4

Description	ID	Northing	Easting	Test Type	Value
DensityQC	1-1-1	4479954.904	499203.845	Density	93.4
DensityQC	1-1-2	4479956.562	499204.392	Density	94.2
DensityQC	1-1-3	4479958.391	499204.436	Density	92.1
DensityQC	1-1-4	4479864.112	499535.026	Density	93.7

Transfer all rover data from the vendor's software in the required format to the Engineer on a daily basis no later than two hours before the start of each succeeding shift.

Intelligent Compaction Daily Report

Prepare and submit the Intelligent Compaction Daily Report (Form 734-5125) on a daily basis no later than two hours before the start of each succeeding shift.

6. TOTAL ROLLER COVERAGE – Submit the Veta reports showing the roller coverage independently for each **Instrumented Roller,** using the cumulative measurement pass count recorded by the instrumented rollers for each **Lot**.

Roller coverage is achieved when the cumulative measurement pass count is greater than or equal to the target pass count as determined by the Control Strip or other ODOT approved target, for each **Instrumented Roller**.

The Engineer will evaluate roller coverage for each for each **Instrumented Roller** independently for compliance.

Calculate Lot Coverage for each lot according to the following equation:

$$Lot\ Coverage = \frac{Lot\ Area\ Covered}{Required\ Lot\ Area}\ X\ 100$$

Where:

Lot Coverage = the percentage of area where data was collected within the given Lot, % (reported to the nearest whole number);

Lot Area Covered = the total measurement pass area where data was collected by an instrumented roller within the given Lot, square feet (reported to the nearest whole number); and

Required Lot Area = total area requiring measurement passes for the given Lot, square feet (reported to the nearest whole number).

Calculate Roller Coverage for each Instrumented Roller per Lot according to the following calculation:

$$Roller\ Coverage = Lot\ Coverage\ X\ Acceptance\ /\ 100$$

Where:

Roller Coverage (RC) = the percent of required compaction area where the minimum required cumulative measurement pass count is achieved for an Instrumented Roller, % (reported to the nearest whole number);

Lot Coverage = the percentage of area where data was collected within the given Lot, % (reported to the nearest whole number);

Acceptance = the percentage of area within the total measurement passes that meets or exceeds the target pass count

Calculate the Total Roller Coverage for each Lot according to the following equation:

$$Total\ Roller\ Coverage = \sum_{j=1}^{m} \frac{Measurement\ Pass\ Length_j}{Lot\ Length} X \frac{Roller\ Target\ Passes_j}{Total\ Target\ Passes} X\ Roller\ Coverage_j$$

Where:

Total Roller Coverage (RC) = the weighted, cumulative Roller Coverage for all Instrumented Rollers for each Lot. (%)

m = the total number of IC Rollers, per lift, per panel, per shift

Measurement Pass Length = the length for which an instrumented roller records measurement passes in a given lot. (to the nearest 0.001 miles)

Lot Length =	the total length of each Lot (to the nearest 0.001 miles)
Roller Target Passes =	the target number of passes for each IC Roller as determined by the Control Strip or other ODOT approved and documented method
Total Target Passes =	the cumulative target number of passes for all Instrumented Rollers as determined by the Control Strip or other ODOT approved and documented method.
Roller Coverage (RC) =	the percent of required compaction area where the minimum required cumulative measurement pass count is achieved for each roller, % (reported to the nearest whole number);