

**DEPARTMENT OF TRANSPORTATION  
STATE OF GEORGIA**

**SPECIAL PROVISION**

**PROJECT NO.  
P. I. NO.**

**Section 416— Intelligent Compaction for Asphaltic Concrete**

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**416.1 General Description:**

This work consists of the construction of Asphaltic Concrete utilizing Intelligent Compaction (IC) rollers within the limits of the work as described in the plans. The work consists of the compaction of the Asphaltic Concrete with a roller equipped to measure and document compaction parameters provided by the roller and positioning, and documenting the locations by use of Real Time Kinematic Global Positioning System (GPS).

This work also consists of providing project specific evaluations based on roller compaction parameters, density (stiffness), material temperature, number of roller passes and other roller parameters that will provide ongoing quality control data to the Engineer.

This work also includes training of Department personnel to manage IC data in accordance with subsection 416.3.02.D.

**416.1.01 Definitions**

IC is defined as a process that uses vibratory rollers equipped with a measurement/documentation system that automatically displays and records various critical compaction parameters including, but not limited to a Intelligent Compaction Measurement Value (IC-MV) that is related to stiffness of in-place material, asphalt temperature, and the location and number of roller passes in real time during the compaction process.

**416.1.02 Related References**

**A. Standard Specifications**

[Section 400](#)

[Section 402](#)

[Section 828](#)

[Section 820](#)

**B. Referenced Documents**

[GDT 39 – Specific Gravity of Compressed Bituminous Mixtures](#)

[GDT 59 – Testing Density of Roadway Materials with Nuclear Gauges](#)

[GDT 73 – Random Selection and Acceptance Testing of Asphaltic Concrete](#)

### **416.1.03 Submittals**

#### **A. Paving Plan**

Before starting asphaltic concrete construction, submit a written paving plan to the Engineer for acceptance. Include the following on the paving plan:

- Proposed starting date
- Location of plant(s)
- Rate of production
- Average haul distance(s)
- Number of haul trucks
- Paver speed feet (meter)/minute for each placement operation
- Asphalt width for each placement operation
- Number and type of rollers for each placement operation
- Sketch of the typical section showing the paving sequence for each placement operation
- Electronic controls used for each placement operation
- Temporary pavement marking plan
- If staged construction is designated in the Plans or contract, provide a paving plan for each construction stage.

#### **B. IC Quality Control Plan (QCP)**

Prepare and submit a written IC Quality Control Plan (QCP) for the project. As a minimum, ensure the QCP contains the following information:

- Detailed Procedure for correlating and verifying GPS for the IC roller(s) and rover(s).
- Detailed Plan and Procedure for the construction of the Test Section to establish target compaction pass counts and target values for the strength of the materials using the standard testing devices, e.g. Nondestructive density gauges, pavement cores, and IC roller(s).
- Procedures for monitoring of the construction operations and the IC roller(s) during production and final evaluation operations.
- Procedures to monitor the ongoing IC data including IC-MV pavement temperature, number of roller passes and the required level of compaction.
- Procedure for monitoring the temperature of the materials during production, transportation, lay-down and compaction operations. Ensure a minimum frequency of one test for two hours of placement is provided and includes all steps in the process.
- Identification of the standard testing device(s) and frequency for monitoring and measuring the in-place density of the asphalt materials. Ensure minimum frequency of tests is in compliance with [GDT 73](#).
- Process and procedure for downloading and analysis of the IC data from the roller(s). Ensure the frequency of obtaining the data from the roller is a minimum of twice per day of asphalt placement and compaction operations. Ensure the data is date/time stamped and permits for external evaluation at a later time.
- Process and Procedure for Pre-construction training for the field personnel including the roller operator(s) regarding the proper operation of the IC technology, including but not limited to: setup of IC rollers, set up of a GPS base station, verification of IC GPS measurement with a hand-held rover, downloading of data from IC rollers, in-situ point test measurements, handling/conversion of GPS data, exporting data

from vendors' IC software to required data format, importing IC data to Veda, and data analysis/reporting with Veda. Contact [www.IntelligentCompaction.com](http://www.IntelligentCompaction.com) for IC training needs.

## **416.2 Materials:**

Ensure that materials comply with the requirements of the plans and Specifications.

Notify the Engineer of the proposed material sources in accordance with Section 400 of the Specifications. Obtain the Engineer's approval to change material sources. The Engineer may sample and test all project materials at any time throughout the duration of the project to assure specification compliance.

## **416.3 Construction Requirements:**

### **416.3.01 Personnel**

Utilize an IC Roller Manufacturer that will provide a qualified representative for on-site technical assistance during the initial seven (7) days of production and then as needed during the remaining operations. Utilize an IC Roller Manufacturer that will, as a minimum, ensure a qualified representative is present during the initial setup and verification testing of the IC roller(s). Utilize an IC Roller Manufacturer that will provide a qualified representative to assist the Contractor with data management using the data analysis software including IC data input and processing.

### **416.3.02 Equipment**

Supply sufficient numbers of IC rollers and other associated compaction equipment necessary to complete the compaction requirements for the specific materials. Leased IC rollers and related equipment may be used on the project. Obtain the Engineer's approval for the equipment used. Ensure that the equipment is in satisfactory mechanical condition and can function properly during production, placement and compaction operations.

#### **A. IC Rollers**

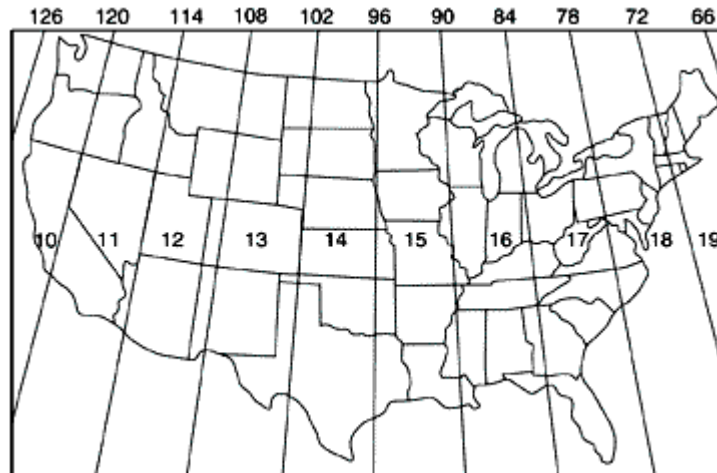
Ensure the IC rollers meet the following specific requirements:

- Are self propelled double-drum vibratory rollers equipped with accelerometers mounted in or about the drum to measure the interactions between the rollers and compacted materials in order to evaluate the applied compaction effort.
- Are equipped with non-contact temperature sensors for measuring pavement surface temperatures.
- The output from the roller is designated as the IC-MV which represents the stiffness of the materials based on the vibration of the roller drums and the resulting response from the underlying materials.
- Are equipped with integrated on-board documentation systems that are capable of displaying real-time color-coded maps of IC measurement values including the stiffness response values, location of the roller, number of roller passes, machine settings, together with the material temperature, speed and the frequency and amplitude of roller drums. Ensure the display unit is capable of transferring the data by means of a USB port.
- Are equipped with mounted Real Time Kinematic Global Positioning System GPS radio and receiver (RTK-GPS) units that monitor the location and track the number of passes of the rollers.

Pre-Qualified IC Intelligent Compaction Rollers for Asphaltic Concrete			
<b>Vendor</b>	Bomag	Sakai	Wirtgen/HAMM
<b>Model</b>	Asphalt Manager	CIS	HCQ
<b>Model Number</b>	BW190AD-4AM	SW850/SW880/SW890	HD 120
<b>IC-MV</b>	Evib	Sakai CCV	HCQ indicator and density estimates
<b>Measurement Unit</b>	MN/m <sup>2</sup>	Unitless	Unitless and % compaction
<b>Documentation Software</b>	BCM Office and Mobile	Aithon AithonMT	HAMM HCQ
<b>Company Address</b>	200 Kentville Road Kewanee, IL 61443	90 International Parkway Adairsville, GA 30103	6030 Dana Way Antioch, TN 37013 USA
<b>Contact Information</b>	Chris Connolly (301) 262-5447 <a href="mailto:Chris.Connolly@bomag.com">Chris.Connolly@bomag.com</a>	Brandon Crockett (800) 3234-0535 ext 205 <a href="mailto:b-rockett@sakaiamerica.com">b-rockett@sakaiamerica.com</a>	Tim Kowalski (615) 594-4604 <a href="mailto:tkowalski@Wirtgenamerica.com">tkowalski@Wirtgenamerica.com</a>

**B. Real Time Kinematic Global Positioning System (RTK-GPS)**

1. Provide RTK-GPS units utilizing the Universal Transverse Mercator (UTM) Coordinates system that divides the surface of Earth between **80°S** and **84°N latitude** into 60 zones, each 6° of longitude in width and centered over a meridian of longitude. Zone 1 is bounded by longitude 180° to 174° W and is centered on the 177th West meridian. Zones outside of the Continental United States can be acquired on the web at [www.dmap.co.uk/utmworld.htm](http://www.dmap.co.uk/utmworld.htm). The UTM for this project is Zone (16-17).



2. Provide Base Station(s) as ground mounted or virtual GPS base units that record values in northing, easting, and the elevation data in meters using the UTM coordinate system along with the longitude/latitude of the measurement values. Ensure the GPS base station broadcasts updated correction data to the GPS receivers on the IC rollers and the hand-held rovers during operations with a survey tolerance of not greater than 1.6 in. (40 mm) in both the horizontal (x and y) directions.

3. Provide and operate a Rover or portable hand-held GPS radio/receiver for in-situ point measurements in conjunction with the IC roller at the direction of the Engineer.
4. Provide an RTK-GPS system that interfaces with the IC rollers' integrated on-board documentation systems and display units so that the GPS data from the IC rollers is displayed to the roller operators on color coded computer screens in "real time" during the roller operation and is saved for transferring and viewing by the Engineer.

**C. Data Analysis Software**

Obtain and utilize standardized data analysis software "Veda" (available on the website [www.IntelligentCompaction.com](http://www.IntelligentCompaction.com)). The software program will utilize the exported IC-MV data from the IC roller for analysis of coverage, uniformity, temperature, and stiffness values during construction operations.

As a minimum, export the following Essential IC Data Information and IC Data Elements from the raw IC data by using IC vendors' software in either ASCII or text format for post processing.

Essential IC Data Information:

Item No.	Description
1	Section Title
2	Machine Manufacture
3	Machine Type
4	Machine Model
5	Drum Width (m)
6	Drum Diameter (m)
7	Machine Weight (metric ton)
8	Name index of intelligent compaction measurement values (IC-MV)
9	Unit index for IC-MV
10	Reporting resolution for independent IC-MVs – 90 degrees to the roller moving direction (mm)
11	Reporting resolution for independent IC-MVs – in the roller moving direction (mm)
12	UTM Zone
13	Offset to UTC (hrs)
14	Number of IC data points

Essential IC Data Elements:

Item No.	Date Field Name	Example of Data
1	Date Stamp (YYYYMMDD)	e.g. 20080701
2	Time Stamp (HHMMSS.S -military format)	e.g. 090504.0 (9 hr 5 min. 4.0 s.)
3	Longitude (decimal degrees)	e.g. 94.85920403
4	Latitude (decimal degrees)	e.g. 45.22777335
5	Easting (m)	e.g. 354048.3
6	Northing (m)	e.g. 5009934.9
7	Height (m)	e.g. 339.9450
8	Roller pass number	e.g. 2
9	Direction index	e.g., 1 forward, 2 reverse
10	Roller speed (kph)	e.g. 4.0
11	Vibration on	e.g., 1 for yes, 2 for no
12	Frequency (vpm)	e.g. 3500.0
13	Amplitude (mm)	e.g. 0.6
14	Surface temperature (oC) - HMA	e.g. 120
15	Intelligent compaction measurement values	e.g. 20.0

Provide Manufacturers recommended compactor, or retrofit, operator settings and user manuals and required software needed to view and export information by the operator and the Department.

**D. Documentation**

Provide IC Project Documentation as follows:

- Quality Control Tests. Submit all asphalt concrete quality control test results to the Engineer within 24 hours of testing.
- Equipment. Provide documentation of the manufacture, model, type of asphalt paver, and rollers used each day of asphalt concrete placement operations including specifically noting the IC roller(s) used and their positioning in the paving operations.
- IC Roller Data. At a minimum, provide the IC Roller Data to the Engineer two times per day during asphalt compaction operations, during the Test Section evaluations, and/or as required by the Engineer. Note the procedures for obtaining the electronic data from IC roller(s) and ensure the data is date/time stamped to permit for external evaluation.
- IC-MV Analysis. The Department will analyze the IC-MV data for conformance to the requirements for coverage area and uniformity. Provide training to Department personnel to manage IC data, including but not limited to: downloading data from IC rollers, in-situ point test measurements, handling/conversion of GPS data, exporting data from vendors' IC software to required data format, importing IC data to Veda, and data analysis/reporting (including correlation analysis between IC data and in-situ point test measurements) with Veda. Contact [www.IntelligentCompaction.com](http://www.IntelligentCompaction.com) for IC training needs.

- Save IC data as Time History Data and Post-Processed Data. Post-Processed Data consists of the all-passes and proofing-data formats. All passes data includes the data from all of the passes and proofing data is the data from just the last pass within a given area.

### **416.3.03 Construction Requirements**

Do not begin work until the Engineer has approved the IC submittals and the IC equipment.

Follow requirements established in Section 400 and Section 402 for production and placement, materials, equipment, acceptance plans and adjustments except as noted or modified in this Specification. Provide the Engineer at least one day's notice prior to beginning construction or prior to resuming production if operations have been temporarily suspended. Ensure paving equipment complies with all requirements specified in Section 400.3.02.C. The IC roller temperatures will be evaluated by the Department with the data from a Paver Mounted Infrared Temperature Bar meeting Special Provision 417.

#### **A. Pre-Construction Test Section(s) Requirements**

1. Prior to the start of production, ensure the proper setup of the GPS, IC roller(s) and the rover(s) by conducting joint GPS correlation and verification testing between the Contractor, GPS representative and IC roller manufacturer using the same datum.

Ensure GPS correlation and verification testing includes the following minimum processes:

- Establish the GPS base station at a location nearby or within the project limits, and tie the IC roller GPS and the GPS rover into the base station; then,
- Verify that the roller and rover are working properly and that there is a connection with the base station; then,
- Record the coordinates of the roller from the on-board, color-coded display; then,
- Remove the receiver from the rover and place it on top of the roller receiver and record the coordinates shown on the rover display; then,
- Compare coordinates between the roller and rover receivers. If the coordinates are within 1.6 in. (40 mm) of each other, the comparison is acceptable. If the coordinates are not within 1.6 in. (40 mm), diagnose and perform necessary corrections and repeat the above steps until verification is acceptable.

Do not begin work until acceptable GPS correlation and verification has been obtained.

Conduct GPS verification testing daily during production operations.

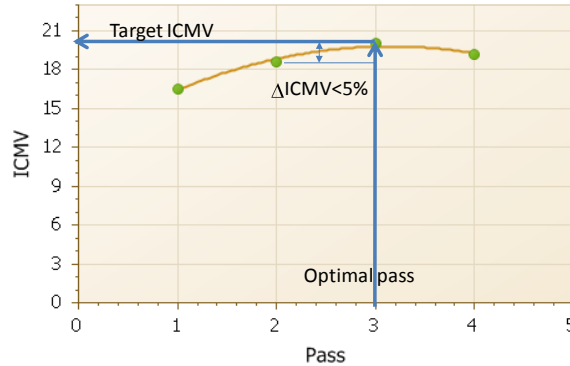
2. Upload the project plan file provided by the Department into the IC Data analysis software and depending on the roller manufacture, the on-board IC computer.

#### **B. Construction Test Section(s) Requirements**

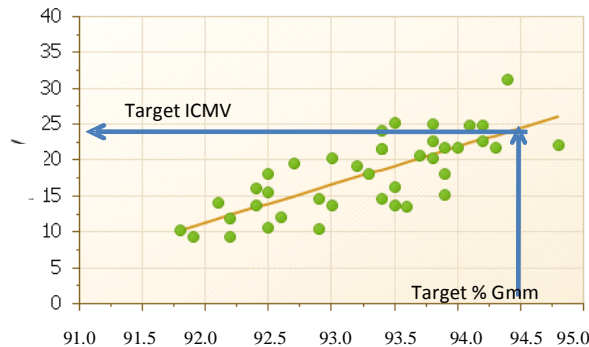
Construct test section(s) at location(s) agreed on by the Contractor and the Engineer within the project limits. The test section is required to determine a compaction curve of the asphalt mixtures in relationship to number of roller passes and to the stiffness of mixture while meeting the Department in-place compaction requirements.

Conduct test section(s) on every lift. Ensure test section quantities are  $\geq 250$  but  $\leq 500$  tons of mainline mixtures. Operate IC rollers in the low to medium amplitude range and at the same settings (speed, frequency) throughout the section while minimizing overlapping of the roller. After each roller pass, the Department will use a nondestructive nuclear gauge that has been calibrated to the mixture to estimate the density of the asphalt at 10 locations uniformly spaced throughout the test section within the width of a single roller pass. The density readings and the number of roller passes needed to achieve the specified compaction will be recorded. The estimated target density will be the peak of the average of the nondestructive readings within the desired compaction temperature range (220°F to 300°F) for the mixture. The IC roller data in conjunction

with the Veda software will create an IC compaction curve for the mixture. The target IC-MV is the point when the increase in the IC-MV of the material between passes is less than 5 percent on the compaction curve. The IC compaction curve is defined as the relationship between the IC-MV and the roller passes. A compaction curve example is as follows:



Subsequent to the determination of the target IC-MV, compact an adjoining  $\geq 250 \leq 500$  tons section using same roller settings and the number of estimated roller passes and allow the Department to verify the compaction with the same calibrated nondestructive nuclear gauge following the final roller pass. The Department will obtain cores at 10 locations, uniformly spaced throughout the test section within the width of the single roller. Obtain GPS measurement of the core locations with a GPS rover meeting the requirements of subsection 416.3.03.A. Use the Veda software to perform least square linear regression between the core data and IC-MV in order to correlate the production IC-MV values to the Department specified in-place air voids. A sample linear regression curve example is as follows.



### C. Construction Requirements

Use the IC roller on all lifts and types of asphalt within the limits of the project.

Ensure the optimal number of roller passes determined from the test sections has been applied to a minimum coverage of 90% of the individual IC Construction area. Ensure a minimum of 70% of the individual IC Construction area meets the target IC-MV values determined from the test sections.

Do not continue paving operations if IC Construction areas not meeting the IC criteria are produced until they have been investigated by the Department. Obtain the Engineer’s approval to resume paving operations.

IC Construction areas are defined as subsections of the project being worked continuously by the Contractor. The magnitude of the IC Construction areas may vary with production but must be at least 750 tons per



mixture for evaluation. Partial IC Construction areas of < 500 tons will be included in the previous area evaluation. Partial IC Construction areas of > 500 tons will constitute a full area to close out the mixture. IC Construction areas may extend over multiple days depending on the operations and in compliance with Section 400.3.06.

The IC Construction Operations Criteria does not affect the Department's acceptance processes for the materials or construction operations.

**416.3.04 Acceptance**

Project compaction acceptance will be based on the Department specification requirements for Maximum Pavement Mean Air Voids as established in Section 400.

**416.4 Measurement:**

The work under this item will be measured as lump sum for payment.

**416.5 Payment:**

Use of the IC equipment will be paid for as lump sum.

Payment will be made under:

Item No. 416	Use of IC rollers and related equipment	Per lump sum
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Office of Materials and Research