

**DEPARTMENT OF TRANSPORTATION  
STATE OF GEORGIA**

**SPECIAL PROVISION  
PROJECT No. STP00-0001-00(817), Clayton/Fulton Counties  
P. I. NO. 0001817  
Section 999- Miscellaneous  
Intelligent Compaction for Soils**

**999.1 General Description:**

This work consists of compacting embankment at fill areas greater than three feet at stations 224+00 to 238+00, and 422+00 to 433+00 using Intelligent Compaction (IC) rollers. The work consists of the compaction the soils materials 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 a project specific evaluations based on roller compaction parameters, stiffness, number of roller passes and other roller parameters that will provide ongoing quality control data to the Engineer.

**999.1.01 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 an Intelligent Compaction Measurement Value (IC-MV) that is related to stiffness of in-place material, and the location and number of roller passes in real time during the compaction process.

**999.1.02 Related References**

A. Standard Specifications

[Section 101 through 150 General](#)  
[Section 208 - Embankments](#)  
[Section 209 - Subgrade](#)

B. Referenced Documents

[GDT 59- Testing Density of Roadway Materials with Nuclear Gauges](#)  
[GDT 67- Family of Curves Method for Determining Maximum Density of Soils](#)

**999.1.03 Submittals**

A. **IC Quality Control Plan (QCP)**

The Contractor shall prepare and submit a written IC Quality Control Plan (QCP) for the project. As a minimum, the QCP shall contain 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. Non-Destructive density gauges and IC rollers(s).
- Procedures or monitoring of the construction operations and the IC roller(s) during production and Procedures to monitor the ongoing IC data including IC-MV stiffness, number of roller passes and the required level of compaction.
- Density/Compaction. Identification of the standard testing device(s) and frequency for monitoring and measuring the in-place density of the soil materials. The minimum frequency of tests shall be in compliance with [Section 208](#).
- Process and procedure for downloading and analysis of the IC data from the roller(s). The frequency of obtaining the data from the roller shall be at a minimum of twice per day during fill construction operations. The data is date/time stamped which permits for external evaluation at a later time.
- Process and Procedure for Pre-construction training for the field personnel including the roller operators(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 IC GPS measurement with a hand-held rover, download data from IC rollers, in-situ point test measurements, handling/conversion of GPS data, ort data from vendors, exporting IC data to Veda, and data analysis/reporting with Veda. Contact [www.IntelligentCompaction](http://www.IntelligentCompaction) for IC training needs.

**999.2 Materials:**

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications in accordance with the Standard Specifications.

Notify the Engineer of the proposed material sources. Notify the Engineer before changing any material source. The Engineer may sample and test project materials at any time throughout the duration of the project to assure specification compliances.

**999.3 Construction Requirements:**

**999.3.01 Personnel**

The Contractor shall coordinate for on-site technical assistance from the IC Roller Manufacturer Representative during the initial seven (7) days of production and then as needed during the remaining operations. As a minimum, the roller representative shall be present during the initial setup and verification testing of the IC roller(s). The roller representative shall also assist the Contractor with data management using the data analysis software including IC data input and processing.

**999.3.02 Equipment**

The Contractor shall supply sufficient numbers of IC rollers and other associated compaction equipment necessary to complete the compaction requirements for the specific materials. The Engineer will approve the equipment used. Ensure that the equipment is in satisfactory mechanical condition and can function properly during production, placement and compaction operations.

The IC rollers shall meet the following specific requirements:

1. IC rollers shall be self propelled single-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. The roller drums may be smooth or pad footed.
2. 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.
3. The IC rollers shall include an integrated on-board documentation system that is 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, speed and the frequency and amplitude of roller drums. The display unit shall be capable of transferring the data by means of a USB port.
4. Roller mounted GPS radio and receiver units shall be mounted on each IC roller. Real Time Kinematic Global Positioning System (RTK-GPS) radio and receivers are required to monitor the location and track the number of passes of the rollers.

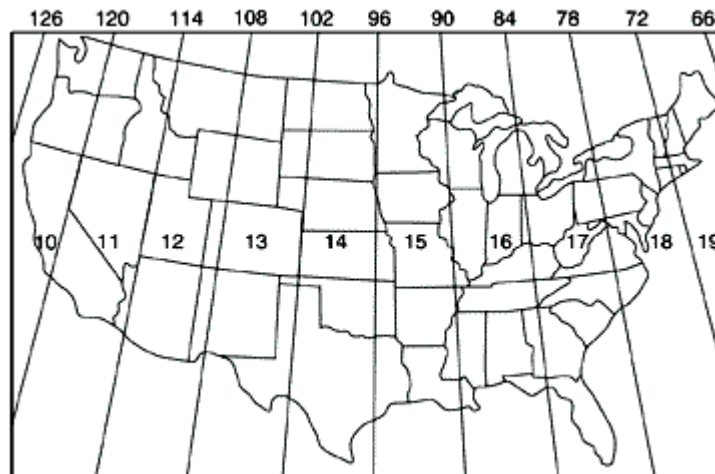
Pre-Qualified IC Intelligent Compaction Rollers for Soils			
Vendor	Bomag	Sakai	Wirtgen/HAMM
Model	Asphalt Manager	CIS	HCQ
Model Number	BW213-4BVC	SV505CIS, SV510CIS, SV610CIS	NA
IC-MV	Evib	Sakai CCV	HCQ indicator
Measurement Unit	MN/m <sup>2</sup>	Unitless	Unitless
Documentation Software	BCM Office and Mobile	Aithon AithonMT	HAMM HCQ
Company Address	2000 Kentville Road Kewanee, IL 61443	90 International Parkway Adairsville, GA 30103	6030 Dana Way Antioch, TN 37013

Contact Information	Chris Connolly (301) 262-5447 Chris.Connolly@bomag.com	Brandon Crockett (800) 3234-0535 ext 205 b-crockett@sakaiaamerica.com	Tim Kowalski (615) 594-4604 Tkowalski@Wirtgenamerica.com
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Pre-Qualified IC Intelligent Compaction Rollers for Soils (continued)			
Vendor	Ammann/Case	Caterpillar	Dynapac
Model	ACEplus		DCA-S
Model Number	SV212	CS56, CS64, CS74, CS76	CA250D, CA260D, CA362D
IC-MV	Kb	CMV	CMV
Measurement Unit	MN/m	Unitless	Unitless
Documentation Software	ACEPlus	AccuGrade	DCA
Company Address	621 State Street Racine, WI 53122	100 North East Adams Street, Peoria, IL 61629	16435 I.H. 35, North Selma, TX 78154
Contact Information	George Whitaker (262) 636-4959 george.whitaker@cnh.com	Kristian Stoekel (763) 315-5588 Stoekel_Kristian_M@cat.com	Gert Hansson (210) 474-5770 gert.hansson@dynapac.com

#### Real Time Kinematic Global Positioning System (RTK-GPS)

- The Universal Transverse Mercator (UTM) Coordinates system 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 I 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).



Base Station- 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 shall be provided. The GPS base station shall broadcast 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.

Rover- A Rover or portable hand-held GPS radio/receiver required shall be provided and operated by the contractor for in-situ point measurements in conjunction with the IC roller at the direction of the Engineer.

The GPS results from the IC roller shall be displayed to the roller operator on a color coded computer screen in "real time" during the roller operation and the data saved for transferring and viewing by the Engineer.

2. Data Analysis Software

Standardized data analysis software "Veda", is 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, the following Essential IC Data Information and IC Data Elements shall be exported 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 (°C) - 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.

Work shall not begin until the Engineer has approved the IC submittals and the IC equipment.

3. Documentation

The Project Documentation shall include:

- Equipment. Documentation of the manufacture and model of the rollers to be used each day of operations.
- IC Roller Data. At a minimum, the procedures for obtaining the electronic data from IC roller(s) shall be noted. The data is date/time stamped which permits for external evaluation, shall be provided to the Engineer at a minimum of two times per day during compaction operations, during the Test Section evaluations, and/or as required by the Engineer.
- IC-MV Analysis. The Department will analyze the IC-MV data for conformance to the requirements for coverage area and uniformity. Department personnel shall be trained to manage IC data, including but not limited to: download data from IC rollers, in-situ point test measurements, handling/conversion of GPS data, export data from vendors' IC software to required data format, import 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.
- IC data will be saved as Time History Data and Post-Processed Data. Post-Processed Data should consist 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.

**999.3.03 Construction Requirements**

Provide training to the roller operator(s) for operations of the equipment and software. Ensure the IC roller manufacturer provides a knowledgeable representative on the project to ensure proper operation of the equipment.

Use of the intelligent compaction IC Roller will be required at fills greater than three feet at the following locations:

Beg. Stat: 224+00 end stat: 238+00

Beg. Stat: 422+00 end stat: 433+00

1. Pre-Construction Test Section(s) Requirements

GPS Correlation and Verification. Prior to the start of production, the Contractor, GPS representative and IC roller manufacturer shall conduct the following to check the proper setup of the GPS, IC roller(s) and the rover(s) using the same datum:

- On a location nearby or within the project limits, the GPS base station shall be established and the IC roller and the GPS rover tied into the base station.
- Verification that the roller and rover are working properly and that there is a connection with the base station.
- The coordinates of the roller from the on-board, color-coded display shall be recorded.
- The receiver from the rover shall be removed and placed on top of the roller receiver and the coordinates shown on the rover display recorded.
- The roller and rover coordinates shall be compared. If the coordinates calculate as being within 1.6 in. (40 mm), the comparison is acceptable. If the coordinates are not within 1.6 in. (40 mm), corrections shall be made as needed and the above steps repeated until verification is acceptable. Work shall not begin until proper verification has been obtained.
- The project plan file provided by the Department shall be uploaded into the IC Data analysis software and depending on the roller manufacture, the on-board IC computer.
- GPS verification testing shall be conducted daily during production operations.

2. Construction Test Section Requirements

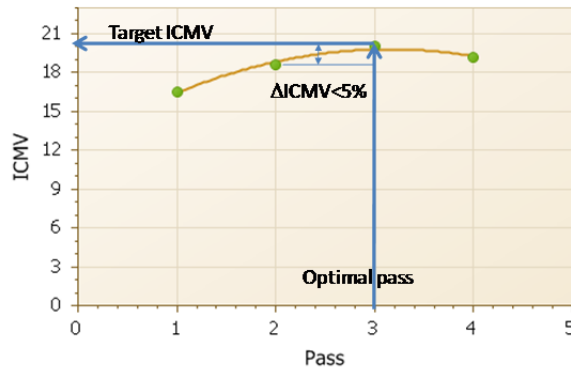
Construct test strip(s) at location(s) agreed on by the Contractor and the Engineer within the project. Complete a control strip using the IC roller to determine the level of compaction necessary to achieve 95% of the maximum dry density in accordance with specifications listed in Section 999.2 Materials depending on the material being compacted. Adjustments to these locations may be requested to assist the Contractor, if it maintains the lengths and fill volumes and is approved by the Office of Materials and Research. Compact the materials in one lift using density control unless otherwise shown on the plans. Compact the material in accordance with the plans and the applicable Specifications listed in Section 999.2 Materials.

Complete at least one control strip to establish a rolling pattern for each layer of material. Construct additional control strips as directed by the Engineer. Leave each control strip in place to become part of the project. Construct the control strip a minimum length of 500 ft (153 m) and 24 ft (8 m) wide and limit the thickness of lifts of compacted material to 8 inches (204 mm) unless otherwise approved by the Engineer. Use the same IC roller and procedures intended for construction of the remainder of the courses.

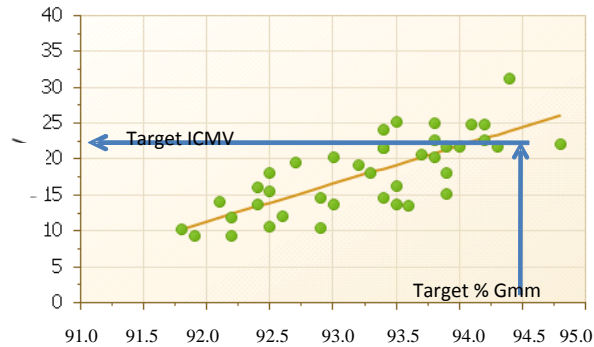
After two passes of the IC roller, the Department will mark and take reading with the moisture density gauge and determine moisture by flame drying a sample in accordance with [GDT-59](#) and [GDT-67](#) at randomly selected test sites at least 2 feet (610 mm) from the edge of the material course. The Department will take additional density and moisture content readings at the original location after every two subsequent passes of the roller.

Continue to compact the control strip until 95% of the maximum dry density is obtained. Determine the moisture content of the material at the beginning of and during compaction in accordance with GDT-59. Maintain moisture during compaction at no less than one (1) percent below the optimum moisture content determined by [GDT-59](#). Proof roll the finished courses over the full width of the course using the same IC roller throughout the project.

The IC roller data in conjunction with the IC data analysis 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 section using same roller settings and the number of estimated roller passes and verify the compaction with the same calibrated nondestructive nuclear gauge following the final roller pass. At 10 locations, tests should be taken uniformly spaced throughout the test section. GPS measurement of the test locations will be obtained with a GPS rover. 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 requirements. Straight line best fit linear regression relationships between the test data and IC-MV will be used to correlate the production IC-MV value to the Department specified in-place density requirements. A sample linear regression curve example is as follows.



3. Construction Requirements

Use of the IC roller is required on all lifts of the fills in the designated limits.

A minimum coverage of 90% of the individual construction area shall meet the optimal number of roller passes determined from the test sections. A minimum of 70% of the individual construction area shall meet the target IC-MV values determined from the test sections. Construction areas not meeting the IC criteria shall be investigated by the Department prior to continuing with the soil operations. The IC Construction Operations Criteria does not affect the Department’s acceptance processes for the materials or construction operations.

IC Constriction areas are defined as subsections of the project being worked continuously by the Contractor. The magnitude of the areas may vary with production and as such the Contractor shall propose to the Engineer the individual construction areas but the minimum area shall be 5000 ft<sup>2</sup> (500 m<sup>2</sup>). Partial construction areas to close out the fill areas may be adjusted and may include areas already evaluated by the IC operations.

4. Rework, re-compact, and refinish material that fails to meet the IC Criteria, the applicable specifications listed in Section 999.2 materials, or that loses require moisture, density, stability or finish before the next course is placed. Continue work until specification requirements are meet with no additional expense to the Department.
5. Pre-construction mapping/proofing of the initial layer of the fill is recommended to identify weak areas that may need to be addressed in advance of the production fill operations. Subsequent mapping may be conducted at anytime to recognize the changes in the fill that affects the target IC-MV or the density verification testing.

**999.3.04 Acceptance**

Final compaction acceptances by the Engineer will be based on the Department-performed field density and moisture content readings in accordance with [GDT-59](#) and [GDT-67](#) and [Section 208](#) of the specifications.

**999.4 Measurement:**

The Work under this item is not measured separately for payment.

**999.5 Payment:**

The Department will not make separate payment for Intelligent Compaction for Soils. Payment will be included at the Contract Unit Price for the items covered by [Section 208](#)

Office of Materials and Research