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INTELLIGENT COMPACTION FOR ASPHALT MIXTURES:

(12-03-13) 610 SP6 R???

Description

This work shall consist of the compaction of asphalt mixtures using Intelligent Compaction (IC) rollers within the 2-mile test section as directed by the Engineer. IC is defined as a process that uses vibratory rollers equipped with a measurement/documentation system that automatically records various critical compaction parameters correlated to agency standard testing protocols in real time during the compaction process. IC uses roller vibration measurements to assess the mechanistic properties of the underlying compacted materials to ensure optimum compaction is achieved through continuous monitoring of the operations.

The Contractor shall supply sufficient numbers of rollers and other associated equipment necessary to complete the compaction requirements for the specific materials. The Contractor will determine the number of IC rollers to use depending on the scope of the project. The primary position for the IC roller is in the initial phase (breakdown) in the paving sequence. IC rollers can also be used in the intermediate phase as long as the mat temperatures are sufficient for compaction. Rollers shall not be used in IC mode during the finish phase of compaction.

All work shall be in accordance with the 2012 *Standard Specifications* and the Department's *Hot Mix Asphalt Quality Management System (HMA/QMS) Manual*.

IC Rollers

The IC roller(s) shall meet the following specific requirements:

(A) IC rollers shall be 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. IC rollers shall also be equipped with non-contact temperature sensors for measuring pavement surface temperatures.

(B) The output from the roller is designated as the Intelligent Compaction Measurement Value (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.

(C) GPS radio and receiver units shall be mounted on each IC roller to monitor the drum locations and track the number of passes of the rollers.

(D) 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, pavement surface temperatures, roller speeds, vibration frequencies and amplitudes of roller drums.

(E) The display unit shall be capable of transferring the data by means of a USB port compatible with VEDA software which is a map-based tool for viewing and analyzing geospatial data.

(F) An on-board printer capable of printing the identity of the roller, the date of measurements, construction area being mapped, percentage of the construction area mapped, target IC-MV, and areas not meeting the IC-MV target values. Use one of the following or an approved equal:

Vendor	**Bomag**	**Sakai**	**Wirtgen/Hamm**
Model	Asphalt Manager	CIS	HCQ
Model No	BW190AD-4AM	SW880/SW890	HD+ 90 / HD+ 110 HD+ 120 / HD+ 140
IC-MV	Evib	CCV	HMV
IC-MV Units	MN/m2	Unitless	Unitless
Documentation	BCM 05 Office	AithonMT-A	HMV
Company Address	Bomag Americas, Inc. 200 Kentville Road Kewanee, Il. 61443	Sakai America, Inc. 90 International Parkway Adairsville, Ga. 30103	Wirtgen America, Inc. 6030 Dana Way Antioch, TN 37013
Contact Information	Chris Connolly (301) 262-5447 Chris.Connolly@ bomag.com	Brandon Crockett (800)-323-0535 B-crockett@ sakaiamerica.com	Tim Kowalski (615) 501-0600 tkowalski@ Wirtgenamerica.com

Notes:

- Evib: Vibration modulus
- HMV: HAMM Measurement Value
- HCQ: HAMM Compaction Quality
- CCV: Compaction Control Value
- CIS: Sakai Compaction Information System

Global Positioning System Definitions

GPS: A space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth to determine the location in geodetic coordinates. In this specification, GPS is referred to all GPS-related signals including US GPS, and other Global Navigation Satellite Systems (GNSS).

Hand-Held GPS rover: A portable GPS radio/receiver for in-situ point measurements.

GPS Base Station: A single ground-based system that consists of a GPS receiver, GPS antenna, radio and radio antenna to provide L1/L2 differential GPS correction signals to other GPS receivers within a range limited by radio, typically 3 miles (4.8 Km) in radius without repeaters.

Network RTK: Network RTK is a system that use multiple bases in real-time to provide high-accuracy GPS positioning within the coverage area that is generally larger than that covered by a ground-based GPS base station; e.g.., VRSTM.

GPS Correction Service Subscription: A service that can be subscribed to receive VRS signals in order to achieve higher accuracy GPS positioning normally via cellular wireless data services; i.e., without the need for a ground-based base station. Examples of GPS Correction Service subscriptions are: Trimble VRSTM, Trimble VRS NOWTM, OmniSTAR, etc.

RTK-GPS: Real Time Kinematic Global Positioning Systems based on the use of carrier phase measurements of the available GPS signals where a single reference station or a reference station network provides the real-time corrections in order to achieve centimeter-level accuracy.

UTM Coordinates: Universal Transverse Mercator (UTM) is a 2-dimentional Cartesian 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. The UTM system uses projection techniques to transform an ellipsoidal surface to a flat map the can be printed on paper or displayed on a computer screen. Note that UTM is metric-based.

Geodetic Coordinates: A non-earth-centric coordinate system to describe a position in longitude, latitude, and altitude above the imaginary ellipsoid surface based on a specific geodetic datum. WGS-84 and NAD83 datum are required for use with UTM and State Planes, respectively.

ECEF XYZ: Earth-Centered, Earth-Fixed Cartesian X, Y, Z coordinates.

Grid: Referred to ECEF XYZ in this specification.

GUI Display: Graphical User Interface Display.

State Plane Coordinate: A set of 124 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. The current State Plane coordinate is based on NAD83. Issues may arise when a project crosses state plane boundaries.

UTC: Coordinated Universal Time (UTC) is commonly referred to as Greenwich Mean Time (GMT) and is based on a 24-hour time scale from the mean solar time at the Earth's prime meridian (zero degrees longitude) located near Greenwich, England.

GPS Requirements

The Contractor shall provide a GPS system that meets the following requirements. The goal of GPS requirements is to achieve accurate and consistent GPS measurements among all GPS devices on the same project. Conversions of GPS data need to be minimized to avoid errors introduced during the process.

All GPS devices for this project shall be set to the same consistent coordinate datum/system no matter whether GPS or Grid data are originally recorded. UTM is the preference and shall be set to Zone No. 17 for this project. The records shall be in meters. Use of UTM will facilitate GPS

data checks onsite. If UTM coordinates are not available, the State Plane Coordinate system can be used.

GPS Check Testing

Prior to the start of production, the Contractor and representatives of the GPS 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:

(A) On a location nearby or within the project limits, the GPS base station (if required by the GPS) shall be established and the IC roller and the GPS rover tied into the same base station.

(B) Verification that the roller and rover are working properly and that there is a connection with the base station.

(C) There are two options for comparing the roller and rover coordinates. Production shall not begin until proper GPS verification has been obtained. IC vendors' recommended verification process can be used to augment either of the following options:

(1) GPS measurement shall be conducted while the IC roller is stationary. The GPS coordinated from the roller on-board display shall be recorded ensuring that the distance offsets are applied correctly to the center of the front drum (e.g., the measurement is at the roller GPS receiver position). Place the hand-held GPS receiver on top of the GPS receiver mounted on the IC roller and record the coordinates from the hand-held receiver display. The differences of the coordinates between the IC roller GPS receiver and hand-held GPS receiver shall be within 2 inches (50 mm) in both the horizontal axes (X and Y). The check for the vertical axis is not required.

(2) A location shall be marked on ground. Move the IC roller so that the center of the front drum is on top of the marked location. Record the GPS measurements from the IC roller ensuring the distance offsets are applied so that the GPS coordinate is at the center of the front drum. Move the IC roller from the marked location and use a hand-held rover to measure at the marked location. The differences of the coordinates in grid shall be within 6 inches (150 mm) in both the horizontal axes (X and Y). On some IC systems, distance offsets are applied to the roller GPS measurements from the on-board display and the coordinates may be on the left or right side of the drum. In those cases move the IC roller so that the left or right side of the front drum axle is flushed with the marked location. Place the hand-held rover right on the marked location and check the difference of both coordinate records. The final GPS coordinate for each IC data point recorded in data files need to be at the center of the front drum.

(D) The project plan file provided by NCDOT shall be uploaded into the IC Data analysis software and depending on the roller manufacture, the on-board IC computer.

(E) GPS check testing shall be conducted daily during production operations to ensure consistency and accuracy of GPS measurements for all GPS devices prior to the paving and compaction operations.

GPS Reference System

Contractor shall provide the GPS system (including GPS receivers on IC rollers and hand-held GPS receivers (Rovers)) that makes use of the same reference system that can be a ground-based base station or network-RTK, to achieve RTK-GPS accuracy. Examples of combinations are:

(A) GPS receivers on IC rollers and hand-held GPS rovers referenced to the same on-ground base station.

(B) GPS receiver on IC rollers and hand-held GPS receivers referenced to the same network RTK.

GPS Data Records and Formats

The recorded GPS data, whether from the IC rollers or hand-held GPS rovers, shall be in the following formats:

(A) Time

The time stamp shall be in military format, hhmmss.ss in either UTC or local time zone. Use 0.01-second increments to differentiate the sequence of IC data points during post process.

(B) GPS

Latitudes and longitude shall be in degrees, minutes, and seconds as a fraction of a minute format, ddmm.mmmmmmmm, or in decimal degrees format, dd.dddddddd. Longitudes are negative values when measuring westward from the Prime Meridian.

(C) Grid

Coordinates shall be in meters with at least 3 digits of significance (0.001 m or 1 mm).

When importing IC-MV data into the data analysis management program, the GPS data and associated IC measurements shall be stored with minimum data conversions and minimum loss of precisions.

Post-Process GPS Check

Follow the vendor-specific instructions to export IC-MV data to VEDA-compatible formats. The Contractor shall import the IC roller data in to VEDA and enter GPS point measurements

from the rover and visually inspect the IC map and point measurements on the VEDA display screen for consistency.

Data Analysis Software

VEDA is available on the website www.intelligentcompaction.com. The software program will use the IC-MV data from the IC roller for analysis of coverage, uniformity, and stiffness values during construction operations. As a minimum, the following Essential IC Data Information and IC Data Elements shall be available for post processing.

Essential IC Data Header Information for Each Data File or Section:

Item No.	Description
H1	Section Title
H2	Machine Manufacture
H3	Machine Type
H4	Machine Model
H5	Drum Width (m)
H6	Drum Diameter (m)
H7	Machine Weight (metric ton)
H8	Name index of intelligent compaction measurement values (IC-MV)
H9	Unit index for IC-MV
H10	Reporting resolution for independent IC-MVs – 90 degrees to the roller moving direction (mm)
H11	Reporting resolution for independent IC-MVs – in the roller moving direction (mm)
H12	UTM Zone
H13	Offset to UTC (hrs)
H14	Number of IC data points

Essential IC Data Elements for Each Data Point:

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 (m)	e.g. 354048.300
6	Northing (m)	e.g. 5009934.900
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) -	e.g. 120
15	Intelligent compaction measurement values	e.g. 20.0
16	Station and Offset	e.g. Sta. 10+00, Offset 3m (RT)

Items 3 and 4 can be exclusive with items 5 and 6, and vice versa. Item 14 is only required for asphalt application. The size of data mesh after post-processing shall be less than 18 inches (450 mm) by 18 inches (450 mm) in the X and Y directions.

Quality Control Plan (QCP)

The Contractor shall prepare and submit a written Quality Control Plan (QCP) for the project. The QCP shall be submitted no later than 30 days prior to commencing the paving operations. As a minimum, the QCP shall contain the following information:

(A) QCP shall be contract-specific, stating how the contractor proposes to control the materials, equipment, and construction operations including subcontractors and suppliers as well as production facilities and transportation modes to the project for the asphalt mixture operations.

(B) The QCP shall include an organizational chart showing all quality control personnel and how these personnel integrate with other management/production and construction functions and personnel.

(C) The QCP shall contain the name, telephone number, duties, and employer of all quality control personnel necessary to implement the QCP. The minimum qualifications of quality control personnel shall be as follows:

(1) QCP Field Manager. The person responsible for the execution of the QCP and liaison with the Engineer. Additionally the QCP Field Manager requirements include:

(a) Full-time employee of the not involved with the Quality Assurance (acceptance) activities on the project.

(b) Minimum 10 years' experience in quality control activities in construction operations. Qualifications shall be included in the QCP.

(c) Full authority to institute actions necessary for successful implementation of the QCP.

(2) Quality Control Technician (QCT). The person(s) responsible for conducting quality control and inspection activities to implement the QCP. There may be more than one QCT on a project.

(a) Full-time employee of the Contractor with a minimum 5 years' experience in quality control activities in construction operations. Qualifications shall be included in the QCP.

(b) Completed the NCDOT requirements for the applicable testing.

(c) Full authority to institute actions necessary for successful implementation of the QCP.

(D) IC Roller Operator(s). The person responsible for operating the IC roller(s) and attached IC equipment. Sufficient training for the roller operator(s) shall be supplied by a representative of the manufacturer of the equipment. Provide documentation of completed training from Manufacturer.

(E) IC Equipment. The roller supplier, make, roller model, number of IC rollers to be provided, and the GPS system supplier to be used.

(F) Temperature Controls: The Contractor shall provide details on their plans to achieve minimum mat temperatures during compaction. IC roller compaction process needs to be completed (final IC roller pass) before the mat temperature fall below a minimum of 240ºF (115ºC) for the initial phase (breakdown) and 200ºF (93ºC) for the intermediate phase.

The NCDOT will review and accept the QCP for compliance with the requirements as stated herein. Asphalt pavement operations shall not begin before the QCP has been accepted.

The QCP shall be maintained to reflect the current status of the operations, and revisions shall be provided in writing prior to initiating the change. The QCP revision shall not be implemented until the revision has been accepted.

If the Contractor is not in compliance with the QCP, then the Engineer has the authority to stop construction operations until the Contractor resolves the issue.

Quality Control Technician (QCT)

The QCT shall be responsible for the following minimum functions:

(A) Daily GPS check testing for the IC roller(s) and rover(s).

(B) Test section construction to establish target compaction pass counts and target values for the strength of the materials using the standard testing devices; i.e., Nondestructive density gauges, pavement cores, and IC roller(s).

(C) Monitoring of the construction operations and the IC roller(s) during production and final evaluation operations.

(D) Quality control testing to monitor the pavement temperature and the required level of compaction.

(E) Daily download and analysis of the IC data from the roller(s).

(F) Daily set-up, take down and secure storage of GPS and IC roller components.

Test Section

Test section evaluations are intended to verify the mixture volumetric of mixtures and determine a compaction curve of the asphalt mixtures in relationship to number of roller passes and to the stiffness of mixture while meeting the NCDOT in-place compaction requirements.

The evaluations shall be conducted every lift and be approximately 300 tons of mainline mixtures. The IC roller in the initial phase shall use low vibration amplitude and the same settings (speed, frequency) throughout the section. After each roller pass, a nondestructive density device shall be used to estimate the density of the asphalt mixture at 5 locations uniformly spaced throughout the test section. The density readings and the number of roller passes that takes to achieve the desired compaction will be recorded.

The estimated target density will be the peak of the nondestructive readings within the desired compaction temperature range for the mixture. The IC roller data using 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% on the compaction curve. The IC compaction curve is defined as the relationship between the IC-MV and the roller passes.

Linear regression relationships between the point test results and the IC-MV results will be used to establish the production target IC-MV as the target density (% G_{mm}) meets the NCDOT in-place compaction requirements.

Mapping

Pre-pave mapping of the underlying materials with an IC roller is required to be completed prior to tacking operations to identify weak areas and may be part of the test section evaluations on the project or independently run. Pre-construction mapping shall be conducted on mainline paving sections. Underlying materials includes treated or non-treated subgrades, treated or non-treated aggregate bases, or on milled or non-milled asphalt pavements. Mapping operations are intended to provide the Contractor an understanding of the stiffness of the existing roadway being paved. Subsequent mapping may be conducted at any time to understand the changes in the roadway that affects the target IC-MV or the density verification testing. The stiffness of the underlying materials should increase with subsequent lifts of asphalt mixtures.

Response to Test Results

The response to quality control tests for the test sections and during production compaction shall include, as a minimum, the following:

(A) Temperature

The procedure for corrective action when the QC or IC temperature readings are not within the recommended laydown values for the mixtures.

(B) Density/Compaction

The procedure for corrective action when the maximum specific density (G_{mm}) results fall below 92.0%.

(C) IC Coverage Area and Uniformity Criteria

The procedures to be taken when the IC criteria for coverage or the minimum IC-MV targets criteria are not being met.

Documentation

A final report including a statement that the test results for quality control and documentation of equipment and IC roller data shall be given to the Department at the completion of the contract. The documentation shall include the following:

(A) Quality Control Tests

The results from the temperature and density testing. All quality control test results shall be signed by the QCT and submitted to the Engineer within 24 hours of testing.

(B) Equipment

Documentation of the manufacture, model, type of paver, and rollers used each day of asphalt materials operations. The positioning of the IC roller(s) in the paving operations shall be noted.

(C) IC Roller Data

At a minimum, the electronic data from IC roller(s) and the data analysis software shall be provided to the Engineer upon the completion of the Test Section, Mapping and individual IC Construction Area operations.

(D) IC Roller Data Analysis

The Contractor will analyze the IC roller data for conformance to the requirements for coverage area and uniformity and will submit the results to the Engineer at the completion of the individual IC Construction Area operations. IC data shall be exported from the vendor's software in both all passes data and proofing data files. 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.

(E) Construction Area

The limits of and total tons of the asphalt mixtures within each construction area.

IC Construction Technical Assistance

The Contractor shall coordinate for on-site technical assistance from the IC roller representatives during the initial 14 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 assist the Contractor with data management using the data analysis software including IC data input and processing.

IC Construction On-Site Training

The Contractor shall coordinate for on-site training for Contractors and Department personnel related to operation of the IC technology. Contractor's personnel shall include the paving superintendent, QC technician(s), and roller operator(s). Department's personnel shall include the Resident Engineer, Roadway Technicians, Materials and Tests representatives, and Construction Unit representatives. Arrangements shall be provided that includes an enclosed facility with electrical availability for visual presentations and should be one-day in duration.

Minimum training topics shall include:

(A) Background information for the specific IC system(s) to be used;

(B) Setup and checks for IC system(s), GPS receiver, base-station and hand held rovers;

(C) Operation of the IC system(s) on the roller; i.e., setup data collection, start/stop of data recording, and on-board display options;

(D) Transferring raw IC data from the rollers(s); i.e., via USB connections;

(E) Operation of vendor's software to open and view raw IC data files and exporting all-passes and proofing data files in Veda-compatible format;

(F) Operation of Veda software to import the above exported all-passes and proofing data files, inspection of IC maps, input point test data, perform statistics analysis, and produce reports for project requirements; and,

(G) Coverage and uniformity requirements.

IC Construction Operations Criteria

A minimum coverage of 90% of the individual construction area shall meet or exceed the optimal number of roller passes and 70% of the individual construction area shall meet or exceed target IC-MV values determined from the test section. Construction areas not meeting the IC criteria (coverage and/or uniformity) will be investigated by the NCDOT prior to continuing with the paving operations. The IC Construction Operations Criteria does not affect the standard NCDOT acceptance processes for the materials or construction operations.

Measurement and Payment

Intelligent Compaction for Asphalt Mixtures will be paid on a lump-sum basis and no measurement will be made for providing for the Intelligent Compaction for Asphalt Mixtures on the project. Lump sum payment for *Intelligent Compaction for Asphalt Mixtures* includes, but is not limited to, all costs related to providing the IC roller(s) including the fuel, roller operator, GPS system, and all equipment required for the IC process; all quality control procedures including, but not limited to, IC rollers and GPS systems representatives support; and on-site training.

Payment will be made under:

Pay Item	**Pay Unit**
Intelligent Compaction for Asphalt Mixtures	Lump Sum