# Intelligent Compaction for HMA

## DESCRIPTION

This work shall consist of the compaction of the asphalt mixtures utilizing intelligent compaction (IC) rollers within the limits of the work as described in the plans. IC is defined as a process that uses vibratory rollers equipped with a measurement/documentation system that automatically records various critical compaction parameters in real time during the compaction process. IC uses roller vibration measurements to assess the mechanistic properties of the 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 shall determine the number of IC rollers to use depending on the scope of the project. The required position for an IC roller is in the initial phase (breakdown) in the paving sequence. Any additional IC rollers shall be used in the intermediate phase.

## EQUIPMENT

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

1. 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 be equipped with non-contact temperature sensors for measuring pavement surface temperatures.

2. The output from the roller is designated as the Intelligent Compaction Measurement Value (IC-MV) which represents the stiffness of the material being rolled based on the vibration of the roller drums and the resulting response from the underlying materials.

3. 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.

4. 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.

5. The display unit shall be capable of transferring the data by means of a USB port.

6. 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 shall be provided.

*The following contact information is provided for three approved vendors. Others may be*

*submitted for approval.*

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

**Global Positioning System (GPS).** The Contractor shall provide GPS technology to achieve accurate and consistent GPS measurements among all GPS equipped devices on the project.

**GPS-Related 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 refers 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.., VRS™.

• 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 VRS™, Trimble VRS NOW™, 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 Plans, 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.

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

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. The Rhode Island State Plane Coordinate shall be used. The records shall be in meters.

Ad-hoc local coordinate systems will not be allowed.

**Construction Requirements.** The Contractor shall provide the GPS system (including GPS receivers on equipment 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:

1. GPS receivers on equipment and hand-held GPS rovers referenced to the same on-ground base station.

2. GPS receiver on equipment and hand-held GPS receivers referenced to the same network RTK.

**GPS Data Records and Formats.** The recorded GPS data, whether from the equipment or hand-held GPS rovers, shall be in the following formats:

1. Time: The time stamp shall be in military format, hhmmss.ss in either UTC or local

time zone. 0.01 second is required to differentiate sequence of data points during post process.

2. GPS: Latitudes and longitude shall in ddmm.mmmmmmmm or decimal degrees, dd.ddddddd. . Longitudes are negative values when measuring westward from the Prime Meridian.

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

When importing data into the data analysis management program, the GPS data and associated measurements shall be stored with minimum data conversions and minimum loss of precisions. Users can then select unit of preference to allow real time unit conversion for the GUI display.

**Post-Process GPS Check.** Follow the vendor-specific instructions to export data to Veda-compatible formats. The Contractor shall import the equipment data into Veda and enter GPS point measurements from the rover and visually inspect the map and point measurements on the Veda display screen for consistency.

**Data Analysis Software**. Standardized data analysis software (Veda) is available on the website www.intelligentcompaction.com. As a minimum, the following Essential Data Information and Data Elements shall be included in each data file or section.

| Item | Description |
|---|---|
| 1 | Section Title |
| 2 | Machine Manufacture |
| 3 | Machine Type |
| 4 | Machine Model |
| 5 | Drum/Screed Width (m) |
| 6 | Drum Diameter (m) (roller only) |
| 7 | Machine Weight (metric ton) |
| 8 | CSPC Zone |
| 9 | Offset to UTC (hrs) |
| 10 | Number of data points |

• Essential Data Elements for Each Data Point:

| Item | 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 | Pass number (rollers only) | e.g. 2 |
| 9 | Direction index | e.g., 1 forward, 2 reverse |
| 10 | Speed (kph) (rollers and pavers) | 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) (rollers only) | e.g. 120 |

Items 3 and 4 can be exclusive with items 5 and 6, and vice versa. 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.

Equipment Operator(s). The person responsible for operating the equipment. Sufficient training for the operator(s) shall be supplied by a representative of the manufacturer of the equipment.

Equipment. The supplier, make, model, unique identifier, and the GPS system supplier to be utilized.

**Quality Control during Rolling:** In addition to any other QC responsibilities, the Contractor shall be responsible for the following:

1. Daily GPS check testing for the equipment and rover(s).

2. Establishing target number of passes using data from standard testing devices; i.e., Nondestructive density gauges, pavement cores, and roller(s).

3. Monitoring the equipment location during paving operations and the operation of the entire GPS system on the project site.

4. Quality control testing to monitor the pavement temperature.

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

6. Daily set-up, take down and secure storage of GPS and equipment components

**Materials Sampling and Testing.**

*A minimum of 95% of the mat must be rolled when analyzed using Veda software. Three 500 foot test sections will be constructed at the beginning of three different locations selected by the Engineer. The test sections shall be rolled six times at 100% coverage to determine the IC-MV values and temperatures.* The minimum frequency of obtaining the data from the equipment shall be two (2) times per day of asphalt compaction operations. The data is date/time stamped which permits for external evaluation at a later time. Data from the on-board printer if required

shall be submitted to the Engineer upon request.

The raw data and results from the analysis software shall be made available to the Engineer within 24 hours of obtaining the data.

**GPS Setup.** Prior to the start of production, the Contractor and representatives of the GPS and equipment manufacturer shall conduct the following to check the proper setup of the GPS equipment and the rover(s) using the same datum:

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

2. Verification that the equipment and rover are working properly and that there is a connection with the base station.

3. There are two options for comparing the equipment and rover coordinates. Production shall not begin until proper GPS verification has been obtained. The vendor's recommended verification process can be used to augment either of the following options:

a. GPS verification measurements shall be conducted while the equipment is stationary. The GPS coordinates from the equipment 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 equipment GPS receiver position). Place the hand-held GPS receiver on top of the GPS receiver mounted on the equipment and record the coordinates from the hand-held receiver display. The differences of the coordinates between the equipment 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.

b. A reference location on the project site shall be selected and marked by the Contractor. The equipment shall be placed so that the center of the front drum is on top of the reference location and the location measurement shall be recorded. After moving the equipment from the marked location, a hand-held rover must be used to locate the reference location. The differences of the coordinates in grid shall be within 6 inches (150 mm) in both the horizontal axes (X and Y). The GPS location measurements from the equipment must be used to determine any offsets that are required so that the GPS coordinate of the equipment is at the center of the front drum or hopper. On some 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 the equipment must be moved so that the left or right side of the front drum axle is flush with the reference location. The hand-held rover must be placed on the marked location and the difference of both coordinate records checked. The final GPS coordinate for each data point recorded in data files must be at the center of the front drum or hopper.

4. The project plan file provided by the Department shall be uploaded into the data analysis software and depending on the equipment manufacturer, the on-board system.

5. GPS setup shall be conducted daily during production operations to ensure consistency and accuracy of GPS measurements for all GPS devices prior to the compaction operation.

**Documentation.** The documentation shall include the following.

1. Equipment. Documentation of the manufacturer and model of the IC rollers used each day of paving. The relative positioning of the equipment in the paving operations shall be noted.

2. Initial Data. At a minimum, the electronic data from equipment and the data analysis software shall be provided to the Engineer upon the completion of the first days paving.

3. Production Roller Data. The Contractor shall export from the vendor's software all data on a daily basis. The Contractor will analyze the equipment data for coverage area and uniformity and will submit the results to the Engineer within 24 hours of the completion of the each day's paving operation.

A summary of all equipment data shall be given to the Department at the completion of the contract.

**Assistance and Training**

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

**On-Site Training.** The Contractor shall coordinate for on-site training for Contractor's and Agency project personnel related to operation of the technology. Contractor's personnel shall include the paving superintendent, QC technicians (if applicable), and equipment operators. Minimum training topics shall include:

1. Background information for the specific system(s) to be used

2. Setup and checks for system(s), GPS receiver, base-station and hand held rovers

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

4. Transferring raw data from the equipment; i.e., via USB connections

5. Operation of vendor's software to open and view raw data files and exporting all-passes and proofing data files in Veda-compatible format

6. Operation of Veda software to import the above exported all-passes and proofing data files,

inspection of maps, input point test data, perform statistics analysis, and produce reports for project requirements

7. Coverage and uniformity requirements of the PPEST specification

**METHOD OF MEASUREMENT**

This item will not be measured as it will be paid as a lump sum for providing the Intelligent Compaction for HMA on the project.

**BASIS OF PAYMENT**

Incorporation of the Intelligent Compaction process will be paid at the contract lump sum price for Intelligent Compaction for HMA**.** *There will be a pro-rated pay adjustment for each day of paving where intelligent compaction technology is not used.*

This item includes all costs related to providing the IC roller(s) including the fuel, roller operator, GPS system, or any other equipment required for the IC process. All quality control procedures including IC rollers and GPS systems representatives, support, on-site training and testing facilities shall be included in the contract lump sum price.