INTELLIGENT COMPACTION TECHNOLOGY FOR ~~HOT MIX ASPHALT~~ BITUMINOUS CONCRETE APPLICATIONS

**From Castleton-West Rutland/Castleton AC STP 2705(1)/2908(1)/2909(1)

xx. DESCRIPTION. This work shall consist of the constructing Hot Mix Asphalt (HMA) utilizing Intelligent Compaction (IC) rollers at the locations indicated in the Plans and as directed by the Engineer.

xx. GENERAL REQUIREMENTS. 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 to ensure optimum compaction is achieved through continuous monitoring of the operations. Additional information on the IC technology may be found at www.intelligentcompaction.com and from the Transportation Research Board - NCHRP Report 676 on Intelligent Soil Compaction Systems.

The Contractor shall supply sufficient IC rollers and other associated standard compaction equipment necessary to complete the compaction requirements for the specific materials.

xx. EQUIPMENT.

(a) IC Rollers.

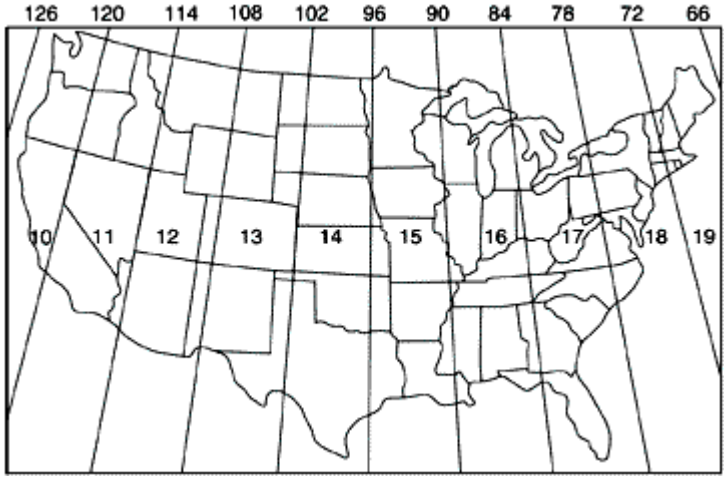
(1) IC rollers shall be self-propelled double-drum vibratory rollers equipped with accelerometers mounted in or about the drum to measure the interactions between the rollers and compacted materials in order to evaluate the applied compaction effort. IC rollers shall also be equipped with non-contact 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 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, and machine settings; together with the temperature, speed, and the frequency and amplitude of the 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. RTK-GPS (see part (b)) radio and receivers are required to monitor the location and track the number of passes of the rollers.

(b) 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 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 found at 18 N.



(c) Base Station. Ground-mounted or virtual GPS base units that record values in northing, easting, and the elevation data in meters or feet 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 40 mm (1.6 inches) in both the horizontal (x and y) directions.

(d) Rover. A portable hand-held GPS radio/receiver for in-situ point measurements shall be provided.

(e) Data Analysis Software. Standardized data analysis software (Veda Beta Vr. 2.0 or later) is available at www.intelligentcompaction.com. The software program will utilize 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 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 (^{o}C) - HMA	e.g. 120
15	Intelligent compaction measurement values	e.g. 20.0

xx. ~~FIELD OPERATIONS~~ BITUMINOUS CONCRETE QUALITY CONTROL PLAN. The Contractor shall prepare and submit a written ~~Field Operations~~ Bituminous Concrete Quality Control Plan (~~FO~~BCQCP) (Plan) for the project. As a minimum, the ~~FO~~BCQCP shall contain the following information:

(a) General Requirements. The Plan as specified within this Subsection shall be separate from any other plan as required by VTrans within the Contract Documents. Bituminous concrete material shall not be produced for any project that has not secured Plan approval as defined under this Subsection.

The Plan shall contain the following minimum information and will be subject to approval by the Engineer:

(1) Name of Plan Administrator and duties (Contractor ~~FO~~BCQCP Personnel/Project Manager)

(2) Name of Field Process Control/Quality Control Technicians and duties (Contractor Foremen)

~~(3) Job mix formulas~~

~~(4) Asphalt plant details~~

~~(5) Stockpile management including RAP and RAS~~

(~~6~~3) Make and type of pavers

(~~7~~4) Make and type of MTV's

(~~8~~5) Make and type of steel drum rollers including total weight and weight per inch of drums

(~~9~~6) Make and type of pneumatic tired rollers and average or recommended ground pressure per tire

(~~10~~7) Mixing/Loading/Transportation

(~~11~~8) Process Control Testing

(~~12~~9) Intended paving/construction sequence

(~~13~~10) Paving limitations

(~~14~~11) Weather limitations

(~~15~~12) Any specific project issues (bridges, drives, intersections, structures, guardrail, other)

The Plan administrator and the field process control/quality control technicians shall be at the liberty and discretion of the Contractor subject to performance.

Form A, as provided herein, shall be completed in full and appended as necessary to have any field Plan be considered complete.

The Contractor shall provide the following additional information as components of the Plan to have the Plan considered for acceptance by VTrans. All components provided shall be titled "Best Practices".

(1) Best Practices for minimizing segregation

~~a. Aggregate Stockpiles~~

~~b. Loading the Silo/Plant delivery~~

~~c~~a. Loading trucks

~~d~~b. Dumping Trucks

~~e~~c. Laydown Operations

~~f~~d. Troubleshooting

~~g~~e. Thermal segregation

(2) Best Practices for screed setup/operators

(3) Best Practices for paver operators

(4) Best Practices for breakdown roller operators

(5) Best Practices for intermediate/finish roller operators

(6) Best Practices for constructing and achieving longitudinal joint compaction

(7) Best Practices for achieving ride quality

(8) Best Practices for MTV usage

(9) Other

The Contractor shall also submit, as part of the Plan, all calculations which reveal hot mix plant daily capacity as intended for the project, anticipated daily field laydown capacity, delivery vehicle availability and capacity, and delivery vehicle route and timing, such that a resultant paver speed as based on the delivery system is provided to VTrans within the Plan indicating a balanced paving operation. Any calculations that may indicate repeated and/or frequent interruption of paver laydown operation will not be approved. Any repeated and/or frequent interruption of paver laydown operation post Plan approval will result in production suspension. The Contractor shall submit any Plan a minimum of five working days prior to any project production. VTrans will review any Plan and provide any comment or approval within five working days of receiving the same. Outlines of that as specified above will be provided by the Engineer upon any request.

Form A

Project Name:			Date:
Project Number:			
VAOT RE:			
VAOT Inspectors:	1.	2.	3.

Contractor Plan Admin:	Roller Operator:
Contractor FOQCP Tech:	Roller Operator:
Contractor FOQCP Tech:	Roller Operator:
Foreman:	Roller Operator:
Paver Operator:	Tack Truck Driver:
Back End:	Laborer:
Back End:	Laborer:
	Laborer:
	Other Personnel:

Mix Type(s)/Gyrations/RAP %:	
AC PG Grade:	Mix Source/Plant Type:

Compaction Spec (Statistical/Average/Method):			
Joint Compaction Spec (Centerline/Shoulder/# Cores):			
Ride Spec (Limited Access/Non Limited/Ride Limits):			
Compacted Thickness:	Base:	Binder:	Top:
Loose Thickness:	Base:	Binder:	Top:

Anticipated Plant TPH:	Anticipated Tons/Day:
No Trucks/Distance From Plant:	Paver Speed:
Paving Widths Expected:	Expected Delays:
Existing Surface/Condition:	Tack Type/Rate:
Designated Truck Turnaround Areas:	Designated Truck Cleanout Areas:
1.	1.
2.	2.
3.	3.
4.	4.
Paver Type(s): 1.	2.
Paver Attachments: Centerline Tapered Joint?	Outside Safety Edge?
Paver Attachments: Joint Heater?	Curbboard Mold?
Paver Automation Type:	Parabolic Required?
Transfer Machine Type:	Remixing Capability?
Tack Truck Type:	

Roller Type	Breakdown	Intermediate	Intermediate	Finish
No of Passes				
Temp Zone				
Speed				
VPM				
Amplitude				

Additionally, as part of or appended to the requirements of the Plan above, the following information shall be provided to satisfy IC requirements:

(1) IC Roller Operator. The person responsible for operating the IC roller and attached IC equipment. Sufficient

training for the roller operator shall be supplied by a representative of the manufacturer of the equipment.

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

(b) IC Monitoring. The ~~FO~~BCQCP technician shall be responsible for the following minimum functions:

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

(2) Test section construction 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).

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

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

(5) Downloading and analysis of the IC data from the roller(s).

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

(c) Materials Sampling and Testing. The procedures for sampling and testing of the pavement shall be identified and shall include as a minimum the following:

(1) Temperature. The frequency and procedure for monitoring the temperature of the materials during production, transportation, laydown, and compaction operations.

(2) Density/Compaction. Identification of the standard testing device(s) and frequency for measuring the in-place density of the HMA.

(3) IC Roller Data. The frequency and procedure for obtaining the IC roller data. The data shall be date/time stamped which permits for external evaluation at a later time.

(d) GPS Check Testing. 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 rover(s) using the same datum:

(1) 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.

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

(3) The coordinates of the roller from the on-board, color-coded display shall be recorded.

(4) 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.

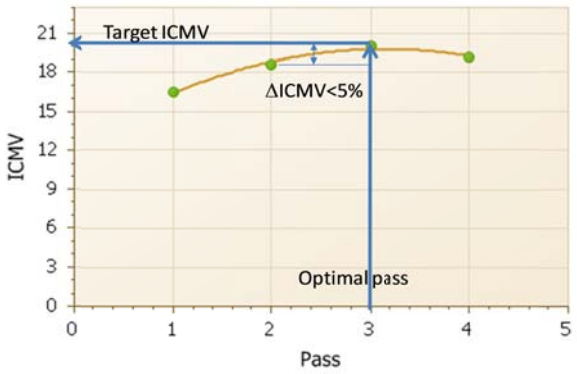
(5) The roller and rover coordinates shall be compared. If the coordinates calculate as being within 40 mm (1.6 inches), the comparison is acceptable. If the coordinates are not within 40 mm (1.6 inches), corrections shall be made as needed and the above steps repeated until verification is acceptable. Work shall not begin until proper verification has been obtained.

(6) The project stationing provided by VTrans shall be uploaded into the IC Data analysis software and depending on the roller manufacture, the on-board IC computer.

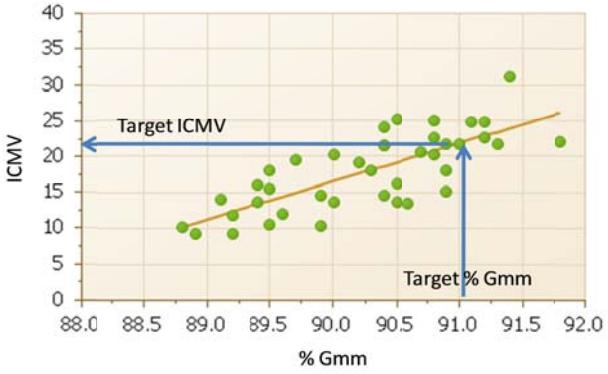
(7) GPS check testing shall be conducted daily during production operations.

(e) Test Sections. Test section evaluations are intended to verify the mixture volumetric of mixtures and determine a compaction curve of the HMA mixtures in relationship to number of roller passes and to the stiffness of mixture while meeting the VTrans in-place compaction requirements.

The evaluations shall be conducted every lift and be approximately 300 metric tons (tons) of mainline mixtures. The IC rollers shall use low amplitude and the same settings (speed, frequency) throughout the section while minimizing overlapping of the roller. After each roller pass, a nondestructive density device shall be used to estimate the density of the HMA 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 required to achieve the desired 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 for the mixture. 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:



Once the target IC-MV is determined, compact an adjoining 300 metric tons (tons) using same roller settings and the number of estimated roller passes and verify the compaction with the same nondestructive devices after the final roller pass. At 10 locations, cores shall be taken uniformly spaced throughout the test section within the width of the single roller. GPS measurement of the core locations will be obtained with a GPS rover. Straight line best-fit linear regression relationships between the core data and IC-MV will be used to establish the production target IC-MV as the target density (% G_{mm}) meets the VTrans in-place compaction requirements. A linear regression curve example is as follows.



(f) Mapping. Pre-paving mapping with an IC roller of the underlying materials is recommended 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 should be approximately 150 m (500 feet) in length and conducted on mainline paving sections. Underlying materials include treated or non-treated subgrades, treated or non-treated aggregate bases, or 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 anytime to understand the changes in the roadway that affect the target IC-MV or the density verification testing. The stiffness of the underlying materials should increase with subsequent lifts of HMA. The Contractor's procedures for mapping shall be included.

(g) 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:

(1) Temperature. The procedure for corrective action when the QC or IC temperature readings are not within the recommended laydown values for the mixture(s).

(2) Density/Compaction. The procedure for corrective action when the roadway specific density results fall below the VTrans specification limits.

(3) IC Coverage Area and Uniformity Criteria. The procedures to be taken when the coverage area for pass counts requirements or IC-MV targets are not being met.

(h) Documentation. Documentation shall include the following:

(1) Quality Control Tests. The results from the temperature and density testing. All quality control test results shall be signed by the FOQCP technician and submitted to the Engineer within 24 hours of testing.

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

(3) IC Roller Data. At a minimum, the electronic data from IC roller(s) shall be provided to the Engineer upon the completion of the test section, mapping, and individual IC construction area operations.

(4) IC-MV Analysis. The Contractor shall analyze the IC-MV 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 will be saved as Time History Data and Post-Processed Data. Post-Processed Data will be imported using 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.

xx. IC CONSTRUCTION.

(a) Technical Assistance. The Contractor shall coordinate for on-site technical assistance from the IC roller 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.

(b) IC Construction Area. IC construction areas are defined as subsections of the project being worked continuously by the Contractor. The magnitude of the evaluation areas may vary with production but they need to be at least 1000 metric tons (tons) per mixture for evaluation. Partial construction areas of 500 metric tons (tons) or less will be included in the previous area evaluation. Partial construction areas of greater than 500 metric tons (tons) will constitute a full area to close out the mixture. Construction areas may extend over multiple days depending on the operations.

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

xx. METHOD OF MEASUREMENT. The quantity of Special Provision (Intelligent Compaction Equipment) to be measured for payment will be on a lump sum basis in the complete and accepted work.

xx. BASIS OF PAYMENT. The accepted quantity of Special Provision (Intelligent Compaction Equipment) will be paid for at the Contract lump sum price. Payment will be full compensation for furnishing the IC roller, including fuel, roller operator, GPS system, or any other equipment required for the IC process; all quality control procedures, including IC rollers, GPS systems representatives' support, and testing facility; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Partial payments will be made as follows:

(a) The first payment of 50 percent of the lump sum price for Special Provision (Intelligent Compaction Equipment) or 5 percent of the adjusted Contract price, whichever is less, will be made with the first biweekly estimate upon completion and acceptance of twenty-five percent of any first lift of bituminous material, excluding leveling, as determined by the Engineer pending progress ~~work~~ on other Contract items.

(b) The second payment of 40 percent of the lump sum price for Special Provision (Intelligent Compaction Equipment) or 5 percent of the adjusted Contract price, whichever is less, will be made on the first estimate upon completion of 50% of any subsequent final or wearing course comlete and accepted or at the completion and acceptance of 75% of the bituminous material on single lift operations.~~following the completion of 50 percent of the Contract, excluding Special Provision (Intelligent Compaction Equipment)~~

(c) Payment of any remaining amount bid for Special Provision (IC for Bituminous Concrete) will be made after the Acceptance Date.

Payment will be made under:

Pay Item	Pay Unit
900.645 Special Provision (~~Intelligent Compaction Equipment~~ IC for Bituminous Concrete)	Lump Sum