proof that the device has been used on previous projects with acceptable safety edge results or construct a safety edge test section prior to the beginning of work and demonstrate the safety edge construction and compaction to the satisfaction of the CO.

401.13. Add the following:

Place warm mix asphalt at temperatures conforming to the warm mix asphalt technology manufacturer's guidelines for lift thickness and road surface temperatures.

Place surface course to maintain the existing edge of pavement. If surface course exceeds the exiting edge of pavement or intermediate asphalt layers, trim surface course in accordance with Subsection 401.15. Trim and/or saw cut pavement and provide 100-foot minimum tapers to match the existing pavement width and re-stripe edge line, if required.

Short sections of handwork to construct the safety edge will be allowed when necessary for transitions and turnouts or otherwise authorized by the CO.

Add the following after Subsection 401.14:

401.14A Intelligent Compaction. If contract option Schedule F or G is exercised, compact the asphalt mixtures using Intelligent Compaction rollers.

Intelligent Compaction is a process that uses vibratory rollers equipped with a measurement/documentation system that automatically records various compaction parameters correlated to standard testing protocols in real time during the compaction process. Intelligent Compaction 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 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.

(a) Intelligent compaction roller(s). Provide Intelligent Compaction roller(s) that meet the following requirements:

(1) Self-propelled double-drum vibratory rollers equipped with:

(a) 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.

(b) Equipped with non-contact temperature sensors for measuring pavement surface temperatures.

(2) Include an integrated on-board documentation system that is capable of displaying

real-time color-coded maps of IC-MV including the stiffness response values, location of the roller, number of roller passes, pavement surface temperature, roller speeds, vibration frequencies and amplitudes of roller drums. Ensure the display unit is capable of transferring the data by means of a USB port.

(3) Include 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.

(4) Include a Global Positioning System (GPS) radio and receiver units mounted on each Intelligent Compaction roller to monitor the drum locations and track the number of passes of the rollers. Ensure the GPS units meet the following requirements:

(a) Set to the Universal Transverse Mercator (UTM) coordinate system, regardless of whether GPS or Grid data are originally recorded. If UTM coordinates are not available, use the State Plane coordinate system. Do not use the local coordinate system. Produce the grid data records are in meters.

(b) Ground-based base station or Virtual Reference Station (VRS) to achieve Real Time Kinematic Global Positioning Systems (RTK-GPS) accuracy. Ensure GPS receivers on Intelligent Compaction rollers and hand-held GPS receivers have the same VRS subscription or reference the same ground-based GPS base station.

(c) Capable of recording GPS data, whether from the Intelligent Compaction rollers or hand-held GPS rovers, in the following formats:

(1) Time stamped be in military format (HHMMSS.SS) in either UTC or local time zone. 0.01 second is necessary to differentiate sequence of Intelligent Compaction data points during post processing.

(2) Provides GPS latitudes and longitudes in DDMM.MMMMMMMM or decimal degrees (DD.DDDDDDDD).

(3) Provides grid coordinates in in meters with at least 3 digits of significance (ie. 001 m or 1 mm).

Provide sufficient numbers of rollers and other associated equipment necessary to complete the compaction requirements. A list of known suppliers of Intelligent Compaction rollers is shown in Table 401-A. The primary position for the Intelligent Compaction roller is in the initial phase (breakdown) in the paving sequence. Intelligent Compaction rollers can also be used in the intermediate phase as long as the mat temperatures are sufficient for compaction. The use of Intelligent Compaction rollers in the finish phase is not recommended.

Table 401-A
Known Contractors of Intelligent Compaction Rollers

Vendor	Bomag	Sakai	Wirtgen/Hamm
Model	Asphalt Manager	CIS (Sakai Compaction Information System)	HCQ (HAMM Compaction Quality)
Model No.	BW 190AD-4AM	SW880/SW890	HD+ 90 / HD+ 110 HD+ 120 / HD+140
IC-MV	Evib (Vibration Modulus)	CCV (Compaction Control Value)	HMV (HAMM Measurement Value)
IC-MV Units	MN/m^2	Unitless	Unitless
Documentation	BCM 05 Office	AithonMT-A	HMV (HAMM Measurement Value)
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

In addition to the acceptance criteria described in Section 401, ensure a minimum coverage of 90 percent of the individual construction area (subsection of the project being continuously worked by the Contractor) meets or exceeds the optimal number of roller passes. Ensure a minimum coverage of 70 percent of the individual construction area meets or exceeds target IC-MV values determined from the control strip.

Coordinate with the Intelligent Compaction roller manufacturer to provide on-site technical assistance during the first 7 days of paving and compaction operations and on an as-needed basis for the duration of the paving and compaction operations. At a minimum, ensure the manufacturer's representative provides assistance during the initial setup and verification testing and also with the data management using the data analysis software (including input and processing of the Intelligent Compaction roller data).

(b) Paving setup. Prior to the start of paving and compaction operations, perform the following to ensure the proper setup of the GPS, hand-held GPS rovers, and Intelligent Compaction rollers:

(1) Establish the GPS base station (if ground-based RTK GPS is used) within the project limits and tie the hand-held GPS rovers and Intelligent Compaction rollers into the same GPS base station.

(2) Verify that the GPS hand-held rovers and Intelligent Compaction rollers are working properly and that there is a connection with the GPS base station.

(3) Compare the Intelligent Compaction roller coordinates to the hand-held GPS rover

coordinates using one of the following methods:

(a) Obtain GPS measurements while the Intelligent Compaction rollers are stationary. Ensure that the offsets are not applied to the center of the front drum (ie. at the receiver position). Place the hand-held GPS rover on top of the GPS receiver mounted on the Intelligent Compaction roller and record the coordinates. Ensure the difference between the coordinates between the hand-held GPS rover and the Intelligent Compaction roller is within 2 inches in both of the horizontal axes (x and y).

(b) Mark a location on the ground and record the coordinates using the hand-held GPS rover. Move the Intelligent Compaction roller so that the center of the front drum is on top of the marked location. Record the coordinates from the Intelligent Compaction roller and ensure the offsets are applied to be at the center of the front drum. Ensure the difference and ensure between the coordinates in grid is within 6 inches in both of the horizontal axes (x and y).

When importing the IC-MV data into the data analysis management program, store the GPS data and associated Intelligent Compaction measurements with minimum data conversions and minimum loss of precisions so that users can then select unit of preference to allow real time unit conversion for the graphical user interface display.

Follow the manufacture's instructions to export the IC-MV data to Veda-compatible formats. Import the Intelligent Compaction roller data into Veda and enter GPS point measurements from the rover and visually inspect the Intelligent Compaction map and point measurements on the Veda display screen for consistency.

Standardized data analysis software (Veda) is available on the website www.intelligentcompaction.com. The software program will use the IC-MV data from the Intelligent Compaction roller for analysis of coverage, uniformity, and stiffness values during construction operations. At a minimum, provide the essential Intelligent Compaction data information and data elements shown in Table 401-B and Table 401-C in either ASCII or text format for post processing.

Table 401-B
Essential Intelligent Compaction Data Header 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

Table 401-C
Essential Intelligent Compaction Data Block Elements

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 (^{O}C) -	e.g. 120
15	Intelligent compaction measurement Values	e.g. 20.0

(c) Quality Control Supervisor (QCS). Training for the Intelligent Compaction will be provided to the QCS during the preconstruction meeting. In addition to the responsibilities described in Section 153, ensure the QCS performs the following:

(1) Daily GPS check testing for the GPS receiver(s) on the Intelligent Compaction roller(s) using a hand-held GPS rover.

(2) Testing of 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).

(3) Monitoring the Intelligent Compaction rollers during production and final evaluation operations.

(4) Daily download and analysis of the Intelligent Compaction data from the rollers. Provide the CO with the daily download and analysis of the Intelligent Compaction data from the rollers within 24 hours.

(5) Daily set-up, take down, and secure storage of GPS and Intelligent Compaction roller components.

(d) Documentation. Submit the following documentation at the completion of paving and compaction operations:

(1) Equipment. The manufacturer, model, and type of paver and rollers used for each day of paving and compaction operations. Ensure the positioning of the IC roller(s) in the paving operations is noted.

(2) Intelligent Compaction roller data and other in-situ test data. The electronic data and analysis from the Intelligent Compaction rollers for each day of paving and compaction operations. Save the Intelligent Compaction roller data as Time History Data and Post-Processed Data. Import the Post- Processed data using the all-passes and proofing-data formats. The all-passes data includes the data from all the passes and the proofing data is the data from just the last pass within a given area. Include all in-situ test data (e.g., nuclear density gauge measurements and associated hand-held rover measurements) including those from the control strip(s).

(3) Construction area. The limits of and total tons of the asphalt mixture within each construction area.

401.15. Delete the second sentence of the first paragraph and substitute the following:

If drop-offs are left overnight, sign the drop-offs in excess of 2 inches with *"Uneven Lanes"* warning signs and provide a 1V:3H fillet for drop-offs in excess of 3 inches.