Intelligent Compaction for Subbase and Reclaimed Stabilized Base (RSB) Applications

DESCRIPTION. This work shall consist of the construction of a subbase and / or RSB, hereafter referred to as aggregate materials, in accordance with Division 300 and 400 and all other applicable Contract requirements. The Contractor shall develop and implement an Aggregate Materials Quality Control Plan (AMQCP), perform quality control testing, and utilize Intelligent Compaction (IC) technology as verification of the required compaction of the aggregate materials. The Agency will perform acceptance testing of the aggregate materials in accordance with those provisions as contained in the Contract documents**.**

GENERAL REQUIREMENTS. IC is defined as a process that uses a soil compaction roller equipped with a compaction measurement and documentation system that automatically records various critical compaction parameters in real time during the compaction process. IC uses roller compaction measurements to assess the mechanistic soils properties and to ensure optimum compaction is achieved through continuous monitoring of the operations.

The Contractor shall supply a sufficient number of rollers and other associated equipment to complete the compaction requirements for the aggregate materials. The IC roller(s) may be utilized during production with other standard compaction equipment, and shall be utilized for the evaluation of the compaction operations. IC rollers shall also be utilized for areas that require chemical modification (cement, CaCl, asphalt, etc.) of the aggregate materials and for the evaluation of the completed aggregate material.

EQUIPMENT.

(a) IC Roller. The IC Roller shall comply with the following requirements:

(1) The roller shall be a self propelled soil vibratory roller equipped with drum accelerometers and smooth or pad footed drums of a weight sufficient to achieve the compaction requirements as specified in the Contract.

(2) The output from the roller representing the stiffness of the materials shall be based on the vibration of the roller and the resulting response from the underlying materials. This value shall be designated as the Intelligent Compaction Measurement Value (IC-MV)

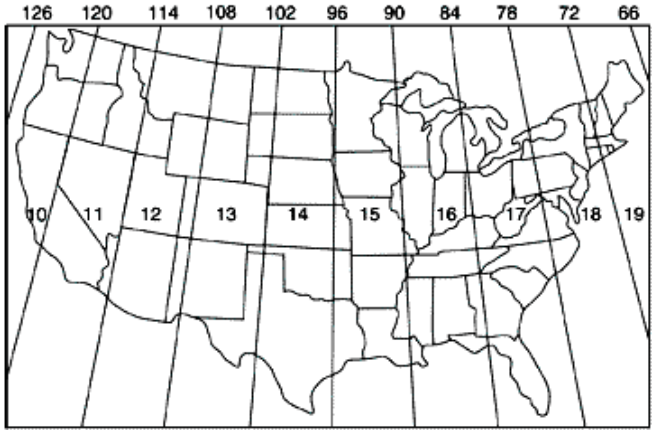
(3) A Real Time Kinematic Global Positioning System (RTK-GPS) radio and receiver shall be mounted on the roller to monitor the location and track the number of passes.

(4) An on-board documentation system showing the location of the roller, number of passes, vibratory amplitude and frequency, and real time color-coded maps of the IC-MV values. The display unit shall be capable of transferring the data by means of a USB port.

(5) A printer, compatible to that data collection system used on the IC roller, shall be provided to the Engineer and be capable of printing the data collected including the quantity of the construction area that was mapped and the quantity of the construction area that met the target IC-MC.

(b) Base Station. Ground mounted or virtual GPS base units that record values in northing, easting, and the elevation data in feet (meters) using the Universal Transverse Mercator (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 roller 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.

The UTM coordinates system divides the surface of the 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. This project is located in Zone 18N.



The state coordinate system being applied on the contract may be used instead of the UTM coordinate system.

(c) Rover. A portable GPS radio/receiver for in-situ point measurements shall be provided and operated by the Contractor.

(d) Data Analysis Software. The latest version of the Veda data analysis software is available at www.intelligentcompaction.com that will utilize the IC- MV data from the IC roller for analysis of coverage, uniformity, and stiffness values. 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 trade name
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 (ICMV)
9	Unit index for ICMV

10	Reporting resolution for independent ICMVs – 90 degrees to the roller moving direction (mm)
11	Reporting resolution for independent ICMVs – in the roller moving direction (mm)
12	UTM Zone or state coordinate system
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)	20080701
2	Time Stamp (HHMMSS.S –military format)	090504.0 (9 hr 5 min. 4.0 s.)
3	Longitude (decimal degrees)	94.85920403
4	Latitude (decimal degrees)	45.22777335
5	Easting (m)	354048.3
6	Northing (m)	5009934.9
7	Height (m)	339.9450
8	Roller pass number	2
9	Direction index	1 forward, 2 reverse
10	Roller speed (kph)	4.0
11	Vibration on	1 for yes, 2 for no
12	Frequency (vpm)	3500.0
13	Amplitude (mm)	0.6
14	Surface temperature (^{o}C) - HMA Only	120
15	Intelligent compaction measurement values	20.0

IC data will be saved as Time History Data and Post-Processed Data. Post-Processed Data will be imported into the data analysis software 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.

AGGREGATE MATERIALS QUALITY CONTROL PLAN. The Contractor shall prepare and submit an aggregate materials quality control plan (AMQCP) for the Contract. As a minimum, the AMQCP shall contain the following information.

(a) General Requirements. The plan as specified within this subsection shall be separate from any other required QC plan as may be specified in the Contract Documents. Manipulation of the existing roadway resulting in aggregate materials or the placement of virgin aggregate materials will not be permitted until such time that the required AMQCP is submitted and approved by the Engineer or representative.

(1) The AMQCP shall be Contract specific and state how the Contractor proposes to control the materials, equipment, and all operations, including any incidental and roadway maintenance activities, on the Contract for the duration of aggregate material operations up until such time that those operations are covered by subsequent project activities.

(2) The AMQCP shall be signed and dated by the Contractor's representative at the time the AMQCP is submitted to the Engineer. The AMQCP shall be submitted 10 working days prior to commencing any aggregate material operations. The Agency will, within five working days, review, sign, and date the AMQCP if the contents of the AMQCP are in compliance with the requirements as stated herein.

(3) 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 AMQCP revision shall not be implemented until the revision has been accepted.

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

a. AMQCP Field Manager. The person responsible for the execution of the AMQCP and liaison with the Engineer. The AMQCP Field Manager shall be a Certified Technician or otherwise qualified as approved by the Engineer for Construction Earthworks.

b. Quality Control Technician. The person responsible for conducting quality control tests and inspection to implement the AMQCP. There may be more than one Quality Control Technician. The Technician shall hold a valid Northeast Transportation Training and Certification Program (NETTCP) Sols and Aggregate Inspector Certification and shall demonstrate knowledge about the use of dynamic cone penetrometers in shallow pavement applications.

c. One quality control technician may perform the duties of the AMQCP Field Manager and the Quality Control Technician upon approval by the Engineer.

d. IC Roller Operator. The person responsible for operating the IC roller and attached IC equipment. Technical / operational training for the roller operator shall be supplied by a representative of the manufacturer of the equipment prior to commencement of any field operation in the presence of the Engineer.

2. The Agency may require the replacement of ineffective or unqualified equipment or Quality Control personnel. Construction operations may be required to stop until appropriate Quality Control operations are taken.

AGGREGATE MATERIALS CONTROL.

(a) References:

(1) AASHTO Standards.

AASHTO T 99	Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
AASHTO T 180	Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 255	Total Moisture Content of Aggregate by Drying
AASHTO T 272	Family of Curves – One-Point Method

(2) ASTM Standards.

ASTM D 6951	Dynamic Cone Penetrometer in Shallow Pavement Applications (17.6-lb (8-kg) hammer)

(b) Quality Control Technician**.** The Quality Control Technician shall be responsible for the following minimum functions:

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

(2) Test section construction and establishing target values for the maximum dry density, optimum moisture content, production moisture content, and strength of the materials using the dynamic cone penetrometer, and IC roller

(3)Monitoring of the construction operations and the IC roller during production and final proofing operations

(4) Quality control testing for the maximum dry density and moisture content

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

(c) Testing Facility. The location of the testing facility and a list of test equipment shall be included in the AMQCP. The testing facility shall be located so that Quality Control test results are provided in a timely manner, be of sufficient size to conduct the Quality Control tests, and have a satisfactory base on which compaction of the aggregate materials in accordance with AASHTO T 99 / T 180 may be conducted. A statement of accessibility of the testing facility shall be included in the AMQCP that allows Agency personnel to witness Quality Control activities, inspect the laboratory, and to review Quality Control tests. A portable testing facility meeting the requirements of that above will be permitted upon the approval of the Engineer.

In addition to that equipment as required for testing herein, the Contractor shall supply a fully functioning and calibrated Dynamic Cone Penetrometer (DCP) for use by the Engineer for the duration of the Contract. A list of the testing equipment proposed for Quality Control testing and

the test methods and frequency of calibration or verification of the equipment shall be included in the AMQCP. The Contractor shall maintain a record of all equipment calibration or verification results at the testing facility. The minimum frequency and procedures shall be as follows:

Equipment	Requirement	Minimum Frequency	Procedure
Balances	Verification	12 months	AASHTO M 231
Sieves	Check Physical Condition	12 months	AASHTO M 92

(d) Materials Sampling and Testing. The procedures for sampling and testing of the aggregate materials and the frequency of tests shall be identified and include as a minimum the following:

(1) Moisture. The procedure for measuring the moisture content of the aggregate materials during production compaction. The minimum frequency of tests shall be one test for each 1400 yd^3 (1000 m^3) of aggregate material manipulated or placed.

(2) Strength. The procedure for measuring the in-place strength of the aggregate material. The minimum frequency of tests shall be one test for each 1400 yd^3 (1000 m^3) of each lift of embankment.

(3) Maximum Dry Density and Optimum Moisture Content. The procedure for measuring the maximum dry density and optimum moisture content of the aggregate materials for the test sections and when there is a change in the soil type

(e) IC Roller Data. The procedure for obtaining the IC roller data shall be included within the AMQCP. The minimum frequency of the Engineer obtaining the data shall be two times each day of compaction with each set of data representing approximately 1/2 of the mapping for each day.

The IC roller data from the data analysis software and test results shall be made available to the Engineer in the testing facility within 24h of obtaining the roller data and the test results.

Aggregate Materials Field Operations Control.

(a) GPS Check Testing. Prior to the start of production, the Contractor, and representatives of the GPS and IC roller manufacturers shall conduct the following to check the proper setup of the GPS, IC roller and rover:

(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 shall be provided.

(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 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. The embankment operations shall not begin until proper verification has been obtained.

(6) Refer to applicable Contract documents for Agency provided files which may be used or manipulated to create necessary field models.

(b) Test Sections. The procedures for constructing the test sections to determine the number of passes of the roller(s) for verification of the Dynamic Cone Penetrometer (DCP) requirements for up to a 12 in. (300 mm) lift shall be included in the QCP. Test sections shall be approximately 100 ft (30 m) long and 20 ft (6 m) wide. The IC roller shall be used on the test sections to establish the IC-MV that corresponds to the DCP test results. GPS measurements for all DCP tests shall be obtained with the rover for correlation to the IC-MV.

(c) Construction Areas. The procedure for determining the construction areas shall be included in the AMQCP. IC construction areas are defined as subsections of the contract being compacted continuously by the Contractor. The area of evaluation may vary with production; however, the minimum construction area evaluated shall be 5000 ft^2 (500 m^2).

(d) Mapping. The procedure for mapping and recording the construction area and stiffness with the IC roller upon completion of the compaction operations for each mapped lift shall be included in the AMQCP. The mapping shall be conducted at least once for intervals not to exceed 24 in. (600 mm) and on the surface of the completed construction.

(e) 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) Moisture. The procedure for corrective action when the moisture tests are not within -3 and +2 percentage points of the optimum moisture content for silt-clay materials and when the moisture tests are not within -6 percentage points of the optimum moisture content for granular materials

(2) Strength. The procedure for corrective action when the results of the DCP testing indicate undercompacted material or "soft spots".

(3) Maximum Dry Density and Optimum Moisture Content. The procedure for corrective action when the maximum dry density and optimum moisture content test results indicate that there is a change in the soil type

(4) IC Coverage Area and Uniformity Criteria. The procedures for re- working the construction areas when IC criteria for coverage area or the minimum IC-MV are not met

(f) Documentation: At the completion of the contract, the Contractor shall provide the following:
(1) Quality Control Tests. The results from the moisture, strength, and maximum dry density and optimum moisture content tests

(2) Equipment. Documentation of the manufacture, model, and type of rollers used each day of soil compaction and the IC roller used for mapping the compaction of the soil

(3) IC Roller Data. The electronic mapping data obtained from the data analysis software for the IC roller. Prior to starting the work, details of data collection, data storage, data sharing, data management, submittal of data, and the data analysis will be provided by the Agency for informational purposes.

(4) Construction Areas. The limits and total area of the construction areas of each lift of aggregate material placed.

IC CONSTRUCTION OPERATIONS.

(a) Technical Assistance. The Contractor shall coordinate for on-site technical assistance from the representative of the IC roller manufacturer during the initial setup, the verification testing of the IC roller on the test section, the initial seven days of production, and as needed during the remaining operations. The IC roller representative shall also assist the Contractor with the data management and analysis using the VEDA data analysis software.

(b) IC Construction Operations Criteria. A minimum of 90 % of the construction area shall be mapped. A minimum of 70 % of the mapped construction area shall equal or exceed the target IC-MV.

COMPACTION ACCEPTANCE.

Acceptance of the compaction will be determined on the basis of tests performed by the Engineer and the IC Construction Operations Criteria.

(a) Test Sections. Test sections shall be constructed in the presence of the Engineer with the available equipment of the Contractor to determine the number of passes of the roller(s) for evaluation of the compacted material based on the DCP test results for up to a 12 in. (300 mm) lift. The IC roller shall be used on the test sections to establish the target IC-MV that corresponds to the DCP test results. GPS measurements for all DCP tests on the test sections shall be obtained with the rover for correlation to the IC-MV. The Engineer will be consulted prior to construction of the test sections to determine the number of test sections required for the evaluation of the DCP testing process. The Engineer will select an area approximately 100 ft (33 m) long and 20 ft (6 m) wide for a test section. The aggregate material in the test section shall meet all Contract requirements. Any aggregate or soil immediately below the test section of which will receive an application of virgin material shall be proofrolled prior to construction of any subsequent lift. An additional test section will be required if there is a change in the type of materials used in any phase of construction. The Contractor may request an additional test section.

(b) Compaction Acceptance with DCP. The compaction acceptance will be determined by average DCP test results in accordance with ASTM D 6951 using a 17.6-lb (8-kg) hammer. The moisture content for silt-clay soils shall be controlled within -3 and +2 percentage points of the optimum moisture content. The moisture content for granular soils shall be controlled within + / - 6 percentage points of the optimum moisture content. The optimum moisture content will be determined in accordance with AASHTO T 99 or T 180 as appropriate.

The Agency will establish the criteria for the DCP acceptance of compaction by performing the sieve analysis, liquid limit, plastic limit, and optimum moisture and maximum density testing in accordance with ASTM D 1140, AASHTO T 89, AASHTO T 90, and AASHTO T 99, respectively, on representative samples of the aggregate materials to be used.

The DCP test results for each construction area for each lift will meet the required DCP values determined for each type of aggregate material. The Engineer will randomly select the location(s) within each construction area for sampling in accordance with the Contractors AMQCP. The frequency of tests will be one test for each 1400 yd^3 (1000 m^3) or fraction thereof for each lift. A construction area less than 1400 yd^3 (1000 m^3) will require one DCP test.

(c) Compaction Acceptance with IC Construction.

(1) Mapped area. A minimum of 90% of the construction area shall be mapped with the IC roller. A printout from the on-board printer of the IC roller shall be submitted to the Engineer for each construction area indicating the total area mapped and the percentage of the mapped area that equals or exceeds the target IC-MV. Documentation of the construction area limits and calculation of the percentage of the construction area mapped shall also be submitted to the Engineer.

(2) IC-MV. Each construction area that is mapped shall have a minimum of 70 % of the mapped area that equals or exceeds the target IC-MV.

(d) Deficient Areas. Individual areas of 1500 ft^2 or more that do not meet the IC-MV target and areas exhibiting excessive pumping or rutting as determined by the Engineer will be considered deficient areas. Deficient areas shall be reworked and will be re-tested and accepted if the IC-MV value meets a minimum of 100% of the target IC-MV. Individual areas less than 1500 ft^2 that do not meet the IC-MV target and do not exhibit excessive pumping or rutting may be accepted if the DCP and moisture content values meet the required acceptance requirements**.**

METHOD OF MEASUREMENT. The quantity of Special Provision (Intelligent Compaction for Subbase and Reclaimed Stabilized Base (RSB) Applications) will be a lump sum basis in the completed and accepted work. No adjustment will be made due to an overrun or underrun of the aggregate material quantities.

BASIS OF PAYMENT. The accepted quantity of Special Provision (Intelligent Compaction for Subbase and Reclaimed Stabilized Base (RSB) Applications) will be paid for at the Contract lump sum price. Payment will be full compensation for furnishing the IC roller(s), fuel, roller operator, GPS system, and any and all other equipment required for the IC process as specified herein, all quality control procedures as specified, GPS support as specified, testing facilities, 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 fifty percent of the lump sum price or 5 percent of the adjusted Contract price, whichever is less, will be made with the first biweekly estimate upon the completion and acceptance of twenty-five percent of any in place RSB, including stabilization, and / or subbase material as determined by the Engineer pending progress on other Contract Items.

(b) The second payment of forty percent of the lump sum price or 5 percent of the adjusted Contract price, whichever is less, will be made on the first biweekly estimate upon the completion and acceptance of seventy-five percent of any in place RSB, including stabilization, and / or subbase material as determined by the Engineer pending progress on other Contract items.

(c) Payment of any remaining amount bid will be made after the Contract substantial completion date as determined by the Engineer.

Payment will be made under:

Pay Item	Pay Unit
900.645 Special Provision (IC for Subbase / RSB)	Lump Sum.