Quality Control/Quality Assurance, QC/QA, Soil Embankment

DESCRIPTION

This work shall consist of the construction of a soil embankment in accordance with 105.03, 203 and 207 and the requirements included herein. The Contractor shall develop and implement a Quality Control Plan (QCP), perform quality control testing, and utilize Intelligent Compaction (IC) technology as part of the Quality Control (QC) of the compaction of the soil embankment. The Department will perform acceptance testing of the soil embankment in accordance with 203 and the subgrade treatment in accordance with 207.

IC, using accelerometer and/or Machine Drive Power (MDP), 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 embankment. The IC roller(s) may be utilized during production, and will be required as part of the Contractors QCP for locations that do not require chemical modification of the soil and for the evaluation of the subgrade at the completion of the subgrade treatment. The Engineer will designate the areas that the IC roller(s) may not be utilized. Acceptance of the subgrade treatment will be in accordance with 207.

EQUIPMENT

IC Roller – The IC Roller shall comply with the following requirements:

1. IC rollers shall be self-propelled static or vibratory rollers equipped with machine drive power and/or with accelerometers mounted in or about the drum to measure the interactions between the rollers and compacted materials to evaluate the applied compaction effort. IC rollers may be smooth or pad footed drums.

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 rolling resistance or 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. An on-board computer display showing the location of the roller, number of passes, amplitude and frequency for vibratory rollers, and real-time, color-coded maps of the IC- MV shall be provided.

5. The display unit shall be capable of transferring the data by means of a USB port or by automatic wireless uploading to a cloud computer system.

6. An on-board printer capable of printing the identity of the roller, the date of measurements, construction area being mapped, quantity of the construction area mapped, target IC-MV, percentage of the construction area that meets the target IC-MV, and locations determined by GPS measurements or stationing not meeting the IC-MV target values.

IC Soils Rollers listed at www.intelligentcompaction.com may be used. Other IC rollers may be approved by the Office of Materials Management.

Global Positioning System (GPS). 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 contract. Conversions of GPS data are required to be minimized to avoid errors introduced during the process.

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 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 uses multiple bases in real-time to provide high-accuracy GPS positioning within the coverage location 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™, or OmniSTAR.

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 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 that may be printed on paper or displayed on a computer screen. 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.

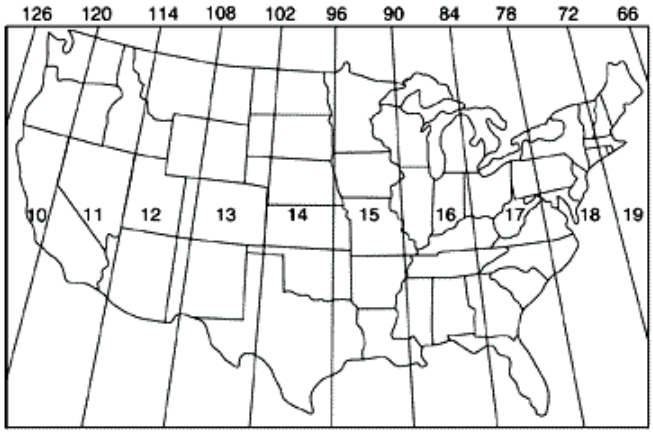
Grid: Referred to ECEF XYZ in this specification.

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. Issues may arise when a contract crosses state plane boundaries.

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 shall be set to the same consistent coordinate datum/system regardless if the GPS or Grid data are originally recorded. UTM is the preference and shall be set to zone no. 16 N for this contract. Zones outside of the continental United States may be acquired on the web at www.dmap.co.uk/utmworld.htm. The records shall be in meters. Use of UTM will facilitate GPS data checks onsite.



The state coordinate system being applied on the contract may be used instead of the UTM coordinate system. The Contractor shall apply corrections to the data to match Veda compatible UTM 16N after uploading and prior to posting on a SharePoint or similar shared Internet site.

Construction Requirements. The 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 may be a ground-based base station, network-RTK, or equivalent, to achieve RTK-GPS accuracy. Examples of combinations are:

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

2. 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:

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 the sequence of IC data points during post process.

2. GPS: Latitudes and longitude shall be in ddmm.mmmmmmmm or decimal degrees, dd.dddddddd. 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 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. Users may then select the unit of preference to allow real time unit conversion for the GUI display.

Data Uploading and Sharing. The Contractor shall establish a system to wirelessly upload all IC data to a secure server system at intervals of 10 minutes or less. The uploaded data shall be used by the Contractor to perform all data processing, conversion, verification and validation steps required herein. Raw and final data (Veda compatible; and separated for each construction area that is mapped) shall be made available on a SharePoint or equivalent Internet site established and maintained for the contract by the Contractor.

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 into 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.

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

Data Analysis Software – Standardized data analysis software (Veda) is available on the website 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 for post processing.

Essential IC Data Information:

Item No.	Description
1	Section Title
2	Machine Manufacturer
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 for each data point:

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*	120
15	Intelligent compaction measurement values	20.0

* Not Applicable for this specification

Items 3 and 4 may be exclusive with items 5 and 6, and vice versa. The size of data mesh after post-processing shall be less than 18 in. by 18 in. in the X and Y directions.

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 construction area.

Alternative to Data Analysis Software - The Contractor may use IC Vendor software instead of uploading the data into Veda. The alternative IC data analysis procedure shall be included in the QCP. All data shall be collected, processed, and shared electronically with the Department in a Veda acceptable format.

QUALITY CONTROL PLAN

The Contractor shall submit a QCP for the contract. As a minimum, the QCP shall contain the following information.

General Requirements

1. The QCP shall be contract specific and state how the Contractor proposes to control the materials, equipment, and operations on the contract for the embankment operations.

2. The QCP shall be signed and dated by the Contractor's representative at the time the QCP is submitted to the Engineer. The QCP shall be submitted 15 days prior to commencing the embankment operations.

3. The Department will review, sign, and date the QCP if the contents of the QCP are in compliance with the requirements as stated herein.

4. 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.

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

    a. QCP Field Manager. The person responsible for the execution of the QCP and liaison with the Engineer. The QCP Field Manager shall be a Certified Technician for Construction Earthworks.

    b. Quality Control Technician. The person responsible for conducting quality control tests and inspection to implement the QCP. There may be more than one Quality Control Technician. The Technician shall be a Qualified Technician for ITM 506, ITM 509, and ITM 512.

    c. One quality control person may perform the duties of the QCP Field Manager and the Quality Control Technician.

    d. 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 to assure that the operator is capable of identifying deficiencies during rolling based on the IC roller real-time data.

6. Embankment operations shall not begin before the QCP has been accepted.

7. The QCP shall include the name of the IC roller(s) supplier, the make and model of the IC roller(s), the number of IC rollers to be used, and the GPS system supplier to be used.

8. The Department 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.

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

2. **ITM Standards**.

ITM 506	Field Determination of Moisture Content of Soils
ITM 509	Field Determination of Strength Using Dynamic Cone Penetrometer
ITM 512	Field Determination of Maximum Dry Density and Optimum Moisture Content of Soil
ITM 513	Soil Test Section Construction
ITM 902	Verifying Sieves
ITM 910	Verifying Balances
ITM 914	Verifying Soil Test Molds
ITM 915	Verifying Soil Hand Compaction Hammers

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 optimum moisture content, production moisture content, and strength of the materials using the one-point proctor with the Department Family of Curves in accordance with ITM 512, Dynamic Cone Penetrometer (DCP), 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 stiffness and moisture content

5. Downloading and analysis of the IC data from the roller

6. Maintenance, completion, and submittal of the Daily Diary, related QC test reports, deficiency analysis, and IC data reporting in either electronic and/or hard copies

Testing Facility. The location of the testing facility and a list of test equipment shall be included in the QCP. The testing facility shall be located so that Quality Control test results are provided to the contract in a timely manner, be of sufficient size to conduct the Quality Control tests, and have a satisfactory base on which compaction of the soil in accordance with AASHTO T 99 (Method A) may be conducted. A statement of accessibility of the testing facility shall be included in the QCP that allows Department personnel to witness Quality Control activities and to review Quality Control tests.

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 QCP. 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	ITM 910
Sieves	Check Physical Condition	12 months	ITM 902
Molds	Check Dimensions	12 months	ITM 914
Rammers	Check Dimensions	12 months	ITM 915

Materials Sampling and Testing. The procedures for sampling and testing of the soil and the frequency of tests shall be identified and include as a minimum the following:

1. Moisture. The procedure for determining the moisture content of the soil during production compaction. The minimum frequency of tests shall be one test for each 1400 yd^3 of each lift of embankment.

2. Strength. The procedure for determining the in-place strength of the soil. The minimum frequency of tests shall be determined by the Contractor.

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

4. IC Roller Data. The procedure for obtaining the IC roller data, using a system to wirelessly upload all IC data to a secure server system at intervals of 10 minutes or less. As an option to this procedure, the Contractor may obtain the data two times each day of soil compaction with each set of data representing approximately 1/2 of the mapping for each day. If there is only one mapping conducted in a day, the data shall be obtained once. The IC roller on-board printer data shall be marked with pertinent information, signed and dated by the QC Technician and given to the Department at the completion of the mapping of each construction area. A copy of the on-board printer data shall be retained by the Quality Control Technician for the daily records of the Technician.

5. Alternative to Data Analysis Software. The procedure for the use of alternative IC Vendor software instead of uploading the data into Veda. The use of the roller printer output is required for all software.

Project Surface Model. The project surface model shall be developed by the Contractor from the plan file provided by the Department. The plan file shall be uploaded into the IC Data analysis software and, depending on the roller manufacturer, the on-board IC computer.

GPS Check Testing. The procedures for GPS check testing shall be included in the QCP. 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 the rover(s) using the same datum:

1. On a location nearby or within the contract 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.

2. Verification that the roller and rover are working properly and that there is a connection with the base station shall be made.

3. Production shall not begin until proper GPS verification has been obtained. The recommended IC vendor verification process may be used to supplement the following method:

   A location shall be marked on the ground. The IC roller is moved so that the center of the front drum is on top of the marked location. The GPS measurements are recorded from the IC roller ensuring the distance offsets are applied so that the GPS coordinate is at the center of the front drum. The IC roller is moved from the marked location and a hand-held rover is used to measure at the marked location. The differences of the coordinates in grid shall be within 6 in. 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, the IC roller is moved so that the left or right side of the front drum axle is flush with the marked location. The hand-held rover is placed on the marked location and the difference of both coordinate records is checked. The final GPS coordinate for each IC data point recorded in data files is required to be at the center of the front drum.

4. 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 compaction operations.

Test Sections. The procedures for constructing the test sections to determine the number of passes of the roller(s) for verification of the DCP requirements for up to a 12 in. lift shall be included in the QCP and be in accordance with ITM 513. Test sections shall be approximately 225 ft long and 24 ft wide and be constructed in a production location. 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.

Construction Areas. The procedure for determining the construction areas shall be included in the QCP. IC construction areas are defined as subsections of the contract being compacted continuously by the Contractor. The construction area of evaluation may vary with production; however, the minimum construction area evaluated shall be 5000 ft^2 and the maximum construction area shall be 75000 ft^2. Construction areas less than 5000 ft^2 being compacted continuously will not be considered a construction area.

Construction areas larger than 75000 ft^2 may be considered. Construction areas may extend over multiple days depending on the operations.

Mapping. Mapping shall be done on each construction area.

The procedures for selecting the appropriate IC roller configuration based on the soil type and 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 QCP. IC rollers may be used in various combinations including smooth drum or pad foot drum, static or vibratory, and accelerometer or MDP.

The procedure for preparing the soil lift prior to mapping shall be included in the QCP. Some roller combinations may require additional grading and/or smooth drum rolling of the soil prior to mapping to achieve representative results during mapping operations.

Proofrolling in accordance with 203.26 will be required to identify weak locations prior to the placement of the first lift of the embankment.

For IC accelerometer type rollers, the initial test section and mapping shall be done after approximately 2 ft of embankment has been placed. At a minimum, additional mapping is required at the final surface of the subgrade or the bottom of the subgrade treatment for locations of chemically modified subgrade, and at the elevation levels of 1.0 ft., 2.0 ft., 4.0 ft., and 8.0 ft. below the final surface of the subgrade, as applicable.

For IC MDP type rollers, the initial test section and mapping shall be done after approximately 1 ft of embankment has been placed. At a minimum, additional mapping is required at the final surface of the subgrade or the bottom of the subgrade treatment for locations of chemically modified subgrade, and at intervals not to exceed 1.0 ft beginning at the elevation level of 8.0 ft below the final surface of the subgrade, as applicable. Mapping may be conducted at any time to recognize the changes in the embankment that affect the target IC-MV or the stiffness verification testing.

Additionally, the subgrade shall be mapped after the completion of the subgrade treatment. Chemically modified subgrade treatment will not be mapped if the IC rollers have significant decoupling during mapping. If decoupling occurs, the subgrade treatment will be accepted by DCP testing and proof rolling in accordance with 215.09.

Soil Management. The procedures for management of the borrow pit and soil cut sections to assure uniform soil material shall be included in the QCP. This includes the procedures that shall be followed for the necessary adjustments in compaction because of a change in soil type.

Response to Test Results. The response to quality control tests for the test sections and during production compaction and IC Construction Quality Control shall include as a minimum the following:

1. Moisture. The procedure for corrective action when the moisture tests are not within -3 percentage points of the optimum moisture content and the optimum moisture content for silty and sandy soils, not within -2 percentage points of the optimum moisture content and + 2 percentage points of the optimum moisture content for clay soils, and not within -6 percentage points of the optimum moisture content and the optimum moisture content for granular soils.

2. Strength. The procedure for corrective action when the blow counts of the DCP tests are less than the required target blow count

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 Deficiency Criteria. The procedures for using GPS, DCP, and the moisture content for determining the size and severity of deficiencies when deficient areas are identified by IC printouts or QC testing. The procedures for re-working deficiencies are required.

5. IC Coverage and Uniformity Criteria. The procedures for re-working the construction areas when the IC criteria for the minimum IC-MV is not met

Documentation.

The Quality Control Technician shall maintain a diary, either electronic and/or hard copy. The diary shall be an open format book with at least one page designated for each day of embankment construction and testing. The diary shall be kept on file until the completion of all earthwork and subgrade operations. Entries in the diary shall as a minimum include:

1. General weather conditions including the amount of rain received on the contract each day
2. Location of common or borrow pit excavation
3. Location of embankment placement and compaction
4. Estimated quantity of embankment placed
5. Time test samples were obtained and tests completed
6. Nonconforming tests and the resulting appropriate action taken
7. Changes in key personnel
8. Significant changes in equipment or operations which may affect the placement or compaction of the embankment
9. IC construction areas, IC-MV results, deficiencies, and response to test results
10. Any significant event or problem

The Quality Control Technician or QCP Field Manager shall sign the entry in the diary. On occasion, the diary may be signed by another person; however, the diary is required to be counter-signed by the Quality Control Technician or QCP Field Manager.

The Contractor shall provide the following documentation at the completion of the soil embankment operations each day:

1. Quality Control Tests. The results from the moisture, strength, and maximum dry density and optimum moisture content tests. All tests shall be clearly documented on hard copies and/or electronically and shall be identifiably related to the test results in the diary.

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, if collected. 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 to the Engineer.

4. Construction Areas. The limits and total construction area of each lift of embankment placed

5. IC-MV Analysis. Analysis of the IC-MV data for conformance to the requirements for coverage and uniformity. The analysis shall be submitted to the Engineer at the completion of the individual IC construction area operations.

   IC data shall be exported from the vendor software in both all passes and proofing data files. All passes data includes the data from all of the passes and the proofing data is the data from just the last pass within a given construction area.

6. Diary. All diary entries

IC CONSTRUCTION QUALITY CONTROL

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 software provided by the Department.

On-Site Training. The Contractor shall coordinate and provide for on-site training for Contractors and Department contract personnel related to operation of the IC technology. Contractor personnel shall include the embankment superintendent, QC technician(s), and roller operator(s). Department personnel shall include the project engineer and field inspector(s). Arrangements shall be provided that includes an enclosed facility with electrical availability for visual presentations and should be 4-8 hours in duration.

Minimum training topics shall include:

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

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

3. Operation of the IC system(s) on the roller; i.e., setup data collection, start/stop of data recording, on-board display options, and transferring raw IC data from the rollers(s); i.e., via USB connections

4. 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

5. 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

6. Coverage and uniformity requirements

Test Sections. Test sections shall be constructed in accordance with ITM 513 with the available equipment of the Contractor to determine the number of passes of the roller(s) for verification of the DCP blow counts for up to a 12 in. 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 soil in the test section shall meet the requirements of 203.09. The soil immediately below the test section in the first lift shall be proofrolled in accordance with 203.26 prior to construction of the lift. An additional test section will be required if there is a change in the soil classification designated in ITM 512 that is used in the embankment. The Engineer may request additional test sections. The target IC-MV may be adjusted after mapping a construction area by correlating the DCP pass/fail boundary of a deficiency with the IC-MV at the same location in accordance with ITM 513.

Mapped Construction Area – 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 in accordance with the QCP documentation requirements for each construction area indicating the total construction area mapped, the percentage of the mapped construction area that equals or exceeds the target IC-MV, and the locations and IC-MV of at least five deficiencies. Documentation of the construction area limits and calculation of the percentage of the construction area mapped shall also be submitted to the Engineer.

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

Deficiencies. Individual locations of 1500 ft^2 or more, or locations of 250 ft^2 or more on the final surface of the subgrade, that do not meet the IC-MV target and locations exhibiting excessive pumping or rutting shall be considered deficiencies.

Deficiencies exhibiting excessive pumping or rutting shall be reworked in accordance with the QCP. Deficient areas will be accepted if the IC-MV for 70% of each reworked deficiency equals or exceeds the target IC-MV or tests conducted by the Contractor of each reworked deficiency indicate that the DCP and moisture content values meet the required acceptance criteria.

Deficiencies of 1500 ft^2 or more, or deficiencies of 250 ft^2 or more on the final surface of the subgrade, that do not exhibit excessive pumping or rutting will be accepted in accordance with the QCP if tests conducted by the Contractor in the deficiency locations indicate that the DCP and moisture content values meet the required acceptance requirements. If the deficiency is reworked in accordance with the QCP, the deficiency location will be accepted if the IC-MV for 70% of each deficiency location equals or exceeds the target IC-MV or tests conducted by the Contractor indicate that the DCP and moisture content values meet the required acceptance criteria.

ACCEPTANCE OF SOIL COMPACTION

Acceptance of the compaction of the soil embankment will be determined on the basis of tests performed by the Engineer and the IC Construction Quality Control.

Compaction Acceptance with DCP. The compaction acceptance will be determined by DCP testing in accordance with ITM 509. The optimum moisture content for silty and sandy soils shall be within -3 percentage points of the optimum moisture content and the optimum moisture content, within -2 percentage points of the optimum moisture content and + 2 percentage points of the optimum moisture content for clay soils, and within -6 percentage points of the optimum moisture content and the optimum moisture content for granular soils. The optimum moisture content will be determined in accordance with ITM 512 for silty, sandy and clay soils and determined in accordance with AASHTO T 99 for granular soils.

The Department 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 90, AASHTO T 267, AASHTO T 99 or ITM 512 respectively, on representative samples of the soils to be used. The required blow counts will be determined based on the laboratory tests for each soil type.

The DCP test results for each construction area for each lift will meet the required DCP values determined for each type of soil. The Engineer will randomly select the location(s) within each construction area for sampling in accordance with ITM 802. The frequency of tests will be one test for each 1400 yd^3 or fraction thereof for each lift. A construction area less than 1400 yd^3 will require one DCP test. Moisture tests will be obtained at a frequency of two tests for each day of embankment construction, or as needed, with each moisture test representing approximately 1/2 of the embankment construction for each day.

When a deficiency is identified at a random location(s), the Contractor shall investigate and correct the deficiency in accordance with the Compaction Acceptance of Deficiencies. The Engineer will subsequently randomly select two additional locations within the remaining construction area for sampling in accordance with ITM 802 and DCP testing in accordance with ITM 509. If one or both of the two additional locations fails to meet the required DCP blow counts, the entire area shall be evaluated by the Contractor in accordance with the QCP and reworked as necessary before acceptance testing is resumed in that area.

Compaction Acceptance of IC Construction Quality Control. The Engineer will review the Contractors ongoing compliance with the QCP and the IC Construction Quality Control requirements. If the Contractor fails to comply with the QCP and IC Construction Quality Control requirements, the Engineer may require mapping of the lift in question or the next lift placed. The Engineer will witness this additional mapping and assure that the Contractor complies with the QCP and the IC Construction Quality Control requirements.

Compaction Acceptance of Deficiencies. Individual locations of 1500 ft^2 or more or locations of 250 ft^2 or more on the final surface of the subgrade that do not meet the DCP or moisture requirements and all locations exhibiting excessive pumping or rutting as determined by the Department will be considered deficiencies.

Deficiencies shall be reworked and will be accepted if the tests conducted by the Contractor of each reworked deficiency indicate that the DCP and moisture content test values meet the acceptance criteria.

Individual locations of less than 1500 ft^2 or locations of less than 250 ft^2 on the final surface of the subgrade that do not meet the DCP or moisture requirements and do not exhibit excessive pumping or rutting as determined by the Department will not be considered deficiencies. These locations may be reworked at the Contractors option in accordance with the QCP.

METHOD OF MEASUREMENT

QC/QA Soil Embankment will not be measured and will be paid as a lump sum for providing all the equipment and support using the QC/QA Soil Embankment process on the contract. No adjustment will be made due to an overrun or underrun of the earthwork quantities. The earthwork will be measured in accordance with 203.

BASIS OF PAYMENT

The QC/QA Soil Embankment process will be paid at the contract lump sum price for QC/QA Soil Embankment.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
QC/QA Soil Embankment with IC .....…….	LS

This item includes all costs related to providing the IC roller including the fuel, roller operator, GPS system, or any other equipment required for the QC/QA Soil Embankment process. All quality control procedures including the QC Plan, IC rollers and GPS systems manufacturer representative support, on-site training, testing facility, construction of test sections, and quality control testing and inspection shall be included in the contract lump sum price for QC/QA Soil Embankment.