

SPECIAL SPECIFICATION

2304

Intelligent Compaction of Soil and Flexible Base

1. **Description.** Construct all areas of embankment, subgrade soil and flexible base (treated or untreated) and all areas of roadway excavation using intelligent compaction (IC) rollers for quality control when shown on the plans or directed by the Engineer.
2. **Terminology.**
 - A. Intelligent Compaction Measurement Values (ICMV) – a set of IC data used to assess the uniformity of compaction based on IC roller vibration measurements.
 - B. Intelligent Compaction Target Value (ICTV) - the average of the roller Intelligent Compaction Measurement Values (ICMV) determined from a control strip.
 - C. Proof Mapping - the process of using an IC roller to map the uniformity and consistency of compaction for the entire section upon completion of compaction.
 - D. VEDA – public domain software available online at <http://www.intelligentcompaction.com>. This computer program is required for use by the Engineer and Contractor to analyze ICMV data and to produce color-coded maps.
3. **Materials.** Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications in accordance with Item 110, “Excavation;” Item 132, “Embankment;” Item 247, “Flexible Base;” Item 251, “Reworking Base Courses;” Item 260, “Lime Treatment (Road-Mixed);” Item 263, “Lime Treatment (Plant-Mixed);” Item 265, “Fly Ash or Lime-Fly Ash Treatment (Road-Mixed);” Item 275, “Cement Treatment (Road-Mixed);” and Item 276, “Cement Treatment (Plant-Mixed).” Notify the Engineer of the proposed material sources. Notify the Engineer before changing any material source. The Engineer may sample and test project materials at any time throughout the duration of the project to assure specification compliance. Use Tex-100-E for material definitions.
4. **Equipment.** Furnish machinery, tools, and equipment necessary for proper execution of the work in accordance with the plans and the applicable Specification Items listed in Section 2304.3, “Materials.”

IC rollers listed in the Department’s Material Producer List, “[Intelligent Compaction Rollers](#)” located at <http://txdot.gov/business/resources/producer-list.html> are preapproved for use. Other accelerometer-based IC systems may be acceptable when the sensitivity of these systems can be demonstrated at the project site and are satisfactory to the Engineer.

Provide the IC system integrated directly from the roller manufacturer or equipped with field IC retrofit kits. IC rollers consist of a stiffness type system that measures and records compaction parameters and a Global Positioning System (GPS) or equivalent system that records and documents roller locations.

Provide IC rollers that have the capability to measure, record, and export compaction parameters in the ASCII format with the Comma Delimited format data files (*.csv) as the preferred method. Deliver the IC data file to the Engineer at the end of each working day. The IC data file shall include, but not limited to, the following parameters:

- Roller Model
- Roller Type
- Roller Drum Width
- Roller Drum Diameter
- Roller Weight
- File Name
- Date Stamp
- Time Stamp
- GPS Measurement Coordinates (includes the coordinate system configuration information, such as State Plane Coordinates and UTM (Universal Transverse Mercator) Zone number, if applicable)
- Roller Pass Count
- Roller Travel Direction (forward or reverse)
- Roller Travel Speed
- Vibration Setting (on or off)
- Vibration Frequency
- Vibration Amplitude
- Intelligent Compaction Measurement Values (ICMV)
- Intelligent Compaction Target Value (ICTV)

Provide a knowledgeable representative from the manufacturer of the IC system during the first two days of construction to ensure proper training, installation, calibration, and operation of the equipment. Ensure personnel of all levels that will be associated with this process attend the on-site training of the IC roller operation provided by the manufacturer's representative. Provide personnel capable to operate and maintain the equipment, collect, save, and provide the data to the Engineer.

Provide a GPS or equivalent system to record IC roller locations with detailed coordinate system information required to generate a color-coded map using the IC data. Furnish a GPS or equivalent reference base station required by the IC roller(s) unless otherwise shown on the plans or as directed by the Engineer.

5. **IC Workshop.** Attend a mandatory IC workshop provided by the Construction Division/Materials & Pavements Section (CST/M&P) after the preconstruction meeting and before the start of construction in accordance with the applicable Specification Items listed in Section 2304.3, "Materials." All Contractor and Engineer personnel involved with all aspects of quality control and assurance of materials are required to attend. This workshop will provide but is not limited to an introduction to IC; development of a Quality Control Plan (QCP) to be used during construction; and data collection, analysis, and reporting using the VEDA program.
6. **Construction.** Construct each layer uniformly, free of loose or segregated areas, and with the required density and moisture content in accordance with the plans and the applicable Specification Items listed in Section 2304.3, "Materials." Provide a smooth surface that conforms to the typical sections, lines, and grades shown on the plans or as directed.
 - A. **Preparation of Subgrade or Existing Base.** Prepare each area to be excavated or to receive embankment or base in accordance with Item 100, "Preparing Right of Way." Proof map the finished surface of the existing ground prior to placement of any material using the IC roller. Deliver the electronic compaction IC data files to the Engineer in the format specified in Section 2304.4, "Equipment" at the end of the working day. The Engineer will use the IC data to generate a color-coded map based on the criteria and colors from Table 1 and Figure 1 using VEDA.
 - B. **Placing.** Spread and shape the materials into a uniform layer in accordance with the plans and the applicable Specification Items listed in Section 2304.3, "Materials."
 - C. **Pulverization.** Pulverize or scarify existing materials in accordance with the plans and the applicable Specification Items listed in Section 2304.3, "Materials."
 - D. **Application of Additives.** Uniformly apply additives in accordance with the plans and the applicable Specification Items listed in Section 2304.3, "Materials."
 - E. **Mixing.** Thoroughly mix the materials with additives in accordance with the plans and the applicable Specification Items listed in Section 2304.3, "Materials."
 - F. **Compaction.** Compact the material in accordance with the applicable Items specified in Section 2304.3, "Materials." Supply a sufficient number of rollers and other associated equipment necessary to complete the compaction requirements for the specific materials based upon the scope of the project. Proof map each completed layer using an approved IC roller only. Use of a roller not equipped with IC technology in lieu of the IC roller is allowed for compaction during placement before proof mapping.
 1. **Control Strip Compaction.** When shown on the plans or as directed by the Engineer, construct a control strip using the IC roller to determine the level of compaction necessary to achieve the density of each material in accordance with the applicable Specification Items listed in in Section 2304.3, "Materials." The Engineer will determine the location(s) within the project to construct the control strip(s), unless otherwise directed. Leave each control strip, accepted by the Engineer, in place to become part of the project.

- a. Complete at least one control strip using an approved IC roller to establish a rolling pattern for the first layer and an Intelligent Compaction Target Value (ICTV) as the control value for further compaction. Construct additional control strips whenever a change is made in the material source, gradation, type of material, layer thickness, IC roller, or as directed by the Engineer.
 - i. Construct the control strip to a minimum length of 500 feet and to the full width of the material course, unless otherwise directed by the Engineer. Place the material in layers per the applicable Items specified in Section 2304.3, "Materials.", unless otherwise directed by the Engineer.
 - ii. Upon complete preparation and proof mapping of the existing ground surface according to Section 2304.6.A, "Preparation of Subgrade or Existing Base," and Section 2304.6.B, "Placing.", place the first layer of material. Start compaction of the material and stop after completing two passes using the IC roller. Mark three random locations at least 2 feet from any edge of the compaction area and take density and moisture content measurements in accordance with Tex-115-E, Part I at all three locations.
 - iii. Continue the compaction process, stop after every two subsequent passes of the roller, and take additional density and moisture content measurements at the same three locations. The Engineer will witness the tests performed and confirm the material achieves the density and moisture content requirements, if applicable. Continue to compact using the same methods specified above and test the control strip until the maximum density from the applicable moisture-density curve is obtained.
 - iv. Proof map the control strip and collect the IC data. Deliver the electronic IC data files to the Engineer by the end of the working day. The Engineer will use the IC data collected from the control strip to establish a roller ICTV and generate a color-coded map based on the criteria and colors from Table 1 and Figure 1 using VEDA for production.

Table 1. Criteria for Color-Coded Map of ICMV Data

Color	Criteria ¹
Red	Area less than 25% of Average ICMV Data
Yellow	Area in the range 25% to 85% of Average ICMV Data
Green	Area greater than 85% of Average ICMV Data

1. The criteria listed in this table are for producing color-coded maps using VEDA software only. Color sequence is listed from lowest to highest stiffness.

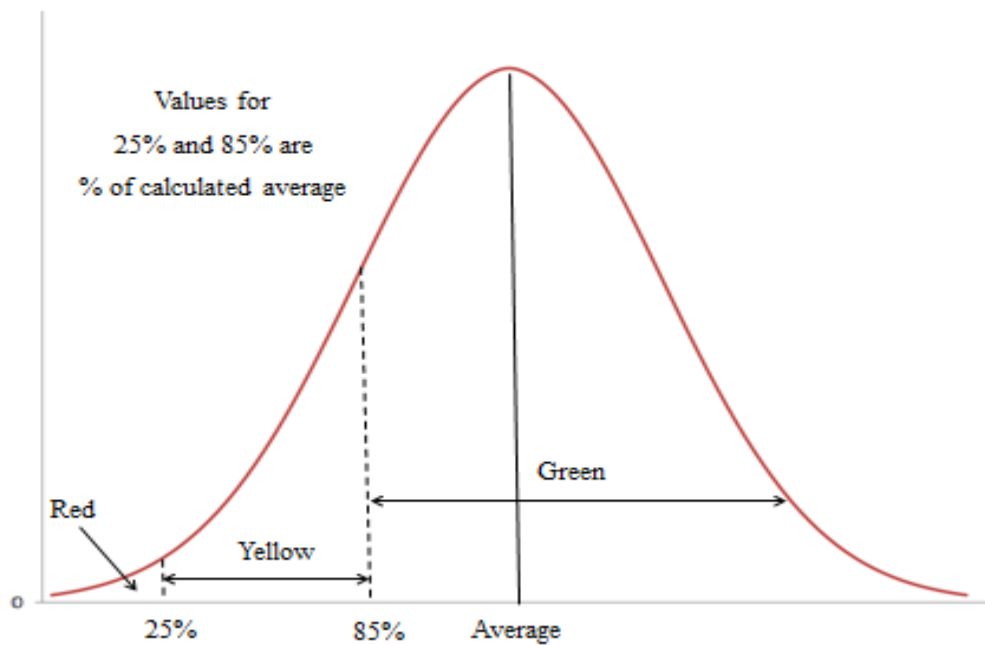


Figure 1
Graph of Criteria for Color-Coded Map of ICMV Data

2. Production Compaction. Compact the materials for each layer using density control, unless otherwise shown on the plans. Compact the materials for final acceptance in accordance with the plans and the applicable Specification Items listed in Section 2304.3, "Materials." When applicable, use the rolling pattern and ICTV determined from the control strip.

Upon completion of compaction for each layer, proof map the layer using an IC roller and collect the IC data before the Engineer determines the roadway density. Deliver the electronic IC data files to the Engineer by the end of each working day. The Engineer will use the IC data to generate a color-coded map based on the criteria of colors from Table 1 and Figure 1 using VEDA. The Engineer may use the color-coded maps as a guide for selecting locations for density measurements and for any other testing for informational purposes only.

G. Finishing. Immediately after completing compaction of the final layer, finish the final section in accordance with the plans and the applicable Specification Items listed in Section 2304.3, "Materials."

H. Curing. Cure the finished section in accordance with the plans and the applicable Specification Items listed in Section 2304.3, "Materials."

7. Measurement and Payment. The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to the pertinent Items.