
Volume I

Section 2.3

EARTHWORK OPERATIONS

2.3.1 PURPOSE

This section describes the project Earthwork Operations, provides a written procedure for the assembly and use of the Earthwork Records System (ERS), and provides guidance for Florida Department of Transportation (Department) responsibilities related to earthwork materials.

2.3.2 SCOPE

The principal users of this document include District Materials and Research Offices (DMROs), District Construction Offices (DCOs), Resident Construction Offices (RCOs), Operations Centers, the State Materials Office (SMO), and the State Construction Office (SCO).

2.3.3 AUTHORITY

Sections 20.23(3)(a) and 334.048(3), Florida Statutes

2.3.4 REFERENCE

Federal-Aid Policy Guide (FAPG), 23CFR, Subchapter G - Engineering and Traffic Operations, Part 637 - Construction Inspection and Approval, Subpart B - Quality Assurance Procedures for Construction

Florida Department of Transportation Standard Specification for Road and Bridge Construction (Specifications)

Florida Department of Transportation Standard Plans for Road and Bridge Construction (Standard Plans)

2.3.5 Sources of Earthwork Material

This section is guidance for those Districts involved in evaluating pits and stockpiles of material prior to construction.

Specifications require contractors to use suitable excavated material or authorized borrow material to prepare subgrades and foundations and to

construct embankments in compliance with the **Standard Plans**.

The Department and the Contractor must perform sufficient material sampling and testing to assure compliance with the **Specifications**. Ultimately, it is the in-place materials at the project that must meet the **Specifications**. Thus, any sampling of material before final placement is designed to reduce the contractor's risk of incurring transportation and placement costs for material that may ultimately fail the in-place requirements. As a result, pit sampling of material should be considered an "as requested" partnering activity.

If the Project Administrator (PA) requests the DMRO to sample a pit or stockpile material, a DMRO representative will visit the pit and acquire representative samples of the materials likely to be used on the project. The DMRO will test the material and report the results in the Department's database.

If the material fails, the Contractor or the PA may request the DMRO representative to return to the pit for a follow-up sampling process. When taking samples, the DMRO representative will offer to perform a split sample with the Contractor. If split, half of the sample will be given to the Contractor for testing and the remaining half would be tested by the Department's Resolution laboratory.

The Resolution laboratory will test the Resolution sample and the results will be reported in the Department's database. If the Resolution laboratory result does not match the Contractor's result, the DMRO may inspect the contractor's laboratory.

2.3.6 NON-ELECTRONIC EARTHWORK RECORDS SYSTEM

The SMO Earthwork Operations Unit is responsible for the ERS procedure. The Non-Electronic ERS is composed of two books, **Contractor Quality Control Density Record Book (Form No. 675-020-27)** and **Verification Density Record Book (Form No. 675-020-28)**, for recording and storing density tests, Proctor sample data, material depth, as well as gauge comparison and calibration records. The instructions contained in the ERS forms shall be properly followed. The ERS may also consist of other forms mentioned in **Section 2.3.11**.

2.3.6.1 Instructions

Construction contracts with roadway earthwork items let before October 1, 2021 shall have a Non-Electronic ERS. The ERS shall be assembled, available for use, and contain all pertinent information. Each contract shall have both a quality control (QC) ERS component with numbered pages and a verification (VT) component. The VT ERS component shall correspond

with the QC page numbering process to cross-reference the LOT number. For convenience, a completely assembled ERS may be temporarily separated by roadway, structure, staged construction, multiple numbered projects, or among density inspectors. Any deviation to the instructions specified in the ERS shall be approved by the District Materials and Research Engineer (DMRE).

2.3.6.2 Preparation

Prior to earthwork construction commencing, properly trained Department project inspection personnel shall, when necessary, guide the Contractor in preparation and organization of the ERS. All ERS graphs shall be computer-plotted and page numbered. The ERS plot program can be downloaded from the SCO website (<https://www.fdot.gov/construction/download>). The **Pipe Backfill Code Sheet (Form No. 675-020-05)** and **Embankment, Subgrade, and Base Code Sheet (Form No. 675-020-06)** are available from the Department's Forms Library located on the Policy and Process Management website (<https://pdl.fdot.gov/Forms>).

2.3.6.3 Plots

Regular roadway earthwork construction consists of either embankment, subgrade, base, or any individual or multiple combinations of these three types. Computer-plotted graphs for regular roadway earthwork construction are required for Density Report sheets. The length of the plots should be such that test locations can be identified adequately. The computer-plotted graphs shall accurately illustrate the required testing (the first to the last lift placed). The Pavement Plot sheet may be used for sections with no embankment. The Pavement Plot sheet is part of the **Contractor Quality Control Density Record System (Form No. 675-020-27)**. A different bar chart is required for each base or subgrade layer, whether using embankment plot sheets, or pavement plot sheets. Any subsequent changes or re-plots that reflect a change from the plan cross-sections shall have a detailed note written on appropriate pages. VT plots may be used at the option of the PA.

All drainage structures and connecting pipe should be accounted for inside and outside the 1:2 (Vertical:Horizontal) slope. A plot is required for all drainage structures and connecting pipe that require testing.

LOTs, as defined in **Specification Section 120** that are shorter than 500 feet may be used for plotting sections of Mechanically Stabilized Earth (MSE) wall construction.

Documentation of Contractor's construction phasing should be clearly identified on the plot page(s). Vertical and/or horizontal lines should be inserted to clearly differentiate between multiple construction phases.

2.3.6.4 Excavation of Unsuitable Materials

All computer-plotted embankment graphs shall be corrected for excavation of unsuitable materials. The anticipated depth of excavation may be coded as an undercut depth on the ***Embankment, Subgrade, and Base Code Sheet (Form No. 675-020-06)*** to provide a blank space for hand corrections. If the graph is re-plotted, make an appropriate note to identify deviation from the plans.

2.3.7 ELECTRONIC ERS

Contracts let on or after October 1, 2021, are required to use the electronic MAC ERS for recording and storing density tests, material depths, gauge comparison and calibration records. Instructions for the use of MAC ERS and additional ERS project requirements can be found on the SMO MAC website (<https://www.fdot.gov/materials/mac>).

2.3.7.1 MAC ERS Preparation

Prior to earthwork construction commencing, DMRO personnel shall guide the Contractor in the preparation of MAC ERS.

2.3.7.2 MAC ERS Plots

Incorporate plots for the electronic ERS into the MAC system. MAC ERS consists of two types of plots: ESB and Drainage. ESB plots are regular roadway earthwork construction that consists of either embankment, subgrade, base, or any individual or multiple combinations of these three types. Drainage plots are specifically for structures and pipes. The length of the plots should be such that test locations can be identified adequately. MAC ERS plotted graphs shall accurately illustrate the required testing (the first to the last lift placed). MAC ERS plots have bar charts for shoulder-only areas or any other areas where pads may be used. Any subsequent changes or re-plots that reflect a change from the Plans shall have a detailed note under the LOT comment section within the MAC ERS.

All drainage structures and connecting pipe should be accounted for inside and outside the 1:2 (Vertical:Horizontal) slope. A plot is required for all drainage structures and connecting pipe that require testing.

LOTS, as defined in **Specifications Section 120** that are shorter than 500 feet may be used for plotting sections of MSE wall construction.

Documentation of the Contractor's construction phasing should be clearly identified on the plot. Vertical and/or horizontal MAC plot lines should be drawn to clearly differentiate between multiple construction phases.

2.3.7.3 Remote Contracts

Contracts without internet connectivity must be designated as a remote contract by the DMRO and must have an ERS Project entry for each Financial Project Number (FPN). The day-to-day testing is recorded on forms **Contractor Quality Control Density Record System (675-020-27)** and **Verification Earthwork Density Record System (675-020-28)**. The density data sheet, stabilizing mixing depth, and base thickness forms specified for MAC ERS shall be used from the official forms to record data to match with the MAC ERS required fields. The data from the forms must be entered into MAC in accordance with the requirements of **Specification Section 105**.

2.3.7.4 Temporary Loss of Internet Connection

Contracts where there is an internet connection and it is temporarily lost or during periods where MAC is not accessible, the Remote Contracts process can be employed until connectivity is restored.

2.3.8 RESPONSIBILITIES OF PERSONNEL

2.3.8.1 Construction Engineering and Inspection

The Department or Consultant Construction Engineering and Inspection (CEI) Inspector shall:

- 1) Ensure accurate sampling and testing per the Contract Documents.
- 2) Ensure recording of test results in the ERS.
- 3) Provide assistance and expertise in the ERS use.
- 4) Perform Quality Assurance (QA) review of the project data, including the Contractor's QC data and VT data for procedural errors and accurate certifiable test records on a minimum weekly basis. For non-electronic ERS, indicate the QA date performed in the ERS. See Appendix A at the end of this chapter for guidance regarding proper

project data review.

- a. The QA review should be performed by a Project Administrator or designated QA personnel.
- 5) Work with the Contractor when evaluating new sources of material.

2.3.8.2 Independent Assurance Personnel

The Independent Assurance (IA) Density Inspector shall:

- 1) Monitor and support the project roadway earthwork Density Inspectors.
- 2) Perform systems-based IA evaluations in accordance with **Materials Manual Section 5.5 - Independent Assurance Program**.
- 3) Oversee the equipment comparison during the Initial Equipment Comparison and as needed during the project.
- 4) Review the ERS for accuracy and completeness.
- 5) Report deficiencies to the PA verbally (if possible), along with a written summary.
- 6) Initial the right-hand margin of the ERS Sheets to indicate what has been reviewed for Non-Electronic ERS entries.

2.3.9 EARTHWORK INSPECTION-IN-DEPTH

On selected projects, a SMO Inspection-In-Depth (IID) Team may inspect the ERS and observe the density and moisture testing activities of personnel responsible for project acceptance. They shall also observe DMRO personnel responsible for the IA. The IID team shall determine the degree of compliance with established standards and issue an inspection report.

2.3.10 ASSESSMENT OF DEFECTIVE MATERIALS

When the requirements of the Materials Acceptance Program are not met as specified in the **Specifications**, the material acceptance will be resolved with the Materials Certification Review process in accordance with **Construction Project Administration Manual (CPAM) 5.8** and **Materials Manual Section 5.4**.

2.3.11 CERTIFICATION OF NON-ELECTRONIC EARTHWORK

RECORDS SYSTEM

At the completion of the project, the Contractor will submit the Non-Electronic ERS to the PA. If requested, the PA will send a copy to the DMRE for review. The Contractor or PA shall resolve all deficiencies to the satisfaction of the DMRE.

2.3.12 TRAINING

Training for Non-Electronic ERS: An ERS training class can be provided upon request to SMO or DMRO. The training includes information concerning the ERS assembly, computer coding to generate earthwork graphs, and the proper use of the completed ERS. Requests for training should be processed through the District Construction Training Administrator. Additional information is available from the State Construction Training Manager.

Training for Electronic ERS: Training for MAC ERS can be provided upon request to the DMRO. Training documentation and training videos can be found on the SMO MAC website.

2.3.13 FORMS

The following forms are available from the Department's Forms Library on the Internet at the following webpage: <https://pdl.fdot.gov/Forms> These non-automated forms should be printed as needed.

ITEM	FORM NO.
Pipe Backfill Code Sheet	675-020-05
Embankment, Subgrade, and Base Code Sheet	675-020-06
Contractor Quality Control Density Record System	675-020-27
Verification Earthwork Density Record System	675-020-28

APPENDIX A MATERIALS GUIDELIST

Ongoing Earthwork Construction

- 1) Is constructed earthwork tested, approved, and accurately documented in the ERS?
- 2) Have quality control (QC) and verification (VT) samples been taken at the appropriate frequency and do they accurately reflect the construction to date?
- 3) Have QC and VT density tests been taken at the appropriate frequency and do they accurately reflect the construction to date?
- 4) Is an Independent Verification density test performed for any QC computed dry density results in a value greater than 105% of the applicable Proctor maximum dry density?
- 5) Have noted deficiencies been corrected?
- 6) Is there a written notification for any reduced frequency testing or use of existing rock?
- 7) Are shipping tickets and certifications collected when materials arrive on site?

Earthwork Records System

- 1) Nuclear Gauge and Initial Equipment Compare Log in data:
 - a. Are the initial equipment comparisons entered?
 - b. Has the comparison been performed and logged if any new gauges are brought to the project?
 - i. Have the calibration records been placed in the ERS?
- 2) Summary of Proctors
 - a. Are QC and VT Proctors properly logged?
 - b. Can the frequency and location of subgrade and base proctor samples be determined from the log-book or from the MAC Summary of Proctor Sample report?

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- i. Do the sample numbers meet the requirements of the ERS?
 - c. Are the verification Limerock Bearing Ratio (LBR) samples labeled with a number that corresponds to the location (LOT No.) where the material was sampled for testing?
 - d. If resolution testing is required for LBR test results:
 - i. Is there a concern with the variability of laboratory test results? If yes, was the resolution sample taken within 10 feet of the original verification sample?
 - ii. Is there a concern with the material consistency in the stabilizing operation? If yes, was the resolution sample taken at a random location within the LOT?
 - iii. Is independent verification (IV) sampling increased for:
 - 1. LBR results frequently falling below the requirements
 - 2. Material variability which may be indicated by varying densities or varying soil classifications
- 3) Roadway Density
- a. Plot Sheets for Non-Electronic ERS Projects
 - i. Are all base, subgrade, curb pads and shoulders plotted with correct thicknesses on jobs that have embankment?
 - ii. Do the elevations match the plans?
 - iii. Did QC personnel initial each plot sheet in the QC logbook verifying plan elevations before data entry on that particular page?
 - iv. Are the plot sheets numbered?
 - v. Are the lifts numbered on the side of the plot sheet?
 - vi. If actual embankment differs from the plans or there is de-mucking or subsoil excavation, have corrections been made to show the change?
 - vii. Is the water table plotted and dated (multiple water tables)?

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- viii. Is the ▼ symbol used to denote the water table and are multiple tables dated?
 - ix. Are lines drawn to clearly delineate phasing?
- b. MAC Plots for Electronic ERS Projects
- i. Are all base, subgrade, curb pads and shoulders plotted with correct thicknesses?
 - ii. Does the existing and proposed elevations match the Design Plans for ESB plots?
 - iii. Did the PA review the plotting data before density was taken?
 - iv. Are the water table lines plotted?
 - v. Are split lot and/or plot lines drawn to clearly delineate phasing?
- c. Roadway Density Sheets for Non-Electronic ERS Projects
- i. Is all header information filled out correctly?
 - ii. Are headings used to identify construction type (embankment, subgrade, base, etc.)?
 - iii. Does the page number match the plot sheet with a letter to designate additional pages?
 - iv. Are lifts affected by water denoted on the graph and density report sheet?

For All Projects:

- v. Do LOT Numbers for Non-Electronic ERS projects and FDOT Sample Numbers for electronic ERS properly filled out to correspond to the appropriate LOTs?
- vi. Is the initial production LOT noted in the ERS?
- vii. Are all completed LOTs tested and verified?
- viii. Did embankment testing begin with the first lift not affected by water?
- ix. Is engineer's approval letter filed with the logbook or placed in the documents tab of MAC if backfill is under wet condition?
- x. Has a test section been taken and verified if compacting 12-inch

thick lifts of AASHTO Soil Class A-1, plastic materials or A-2-4 materials with greater than 15% fines?

- xi. Is test data filled out correctly and completely?
- xii. Is there a verification density test for any QC density greater than 105% compaction?
- xiii. Have all failing density tests been properly accounted?
- xiv. Are lifts constructed but not tested because of reduced frequency documented?

4) Retaining Wall Systems

- a. Are project personnel using the same proctor and acceptance requirements for density?
- b. Do LOT Numbers for non-electronic ERS projects and FDOT Sample Numbers for electronic ERS correspond to the appropriate LOTs?
- c. Is there a density test for each density requirement for each lift of material?
- d. Is embankment between the Reinforced Wall backfill considered compacted in one operation?
- e. Are there any spread footings in the wall backfill?
- f. Is metallic soil reinforcement being used at the wall?

5) Pipe and Drainage Structures

- a. Plot Sheets
 - i. Are structure and pipe run plots representative of the plans?
 - ii. Have elevations been checked and verified?
 - iii. Are lifts numbered and verified to be correct?
 - iv. Are density tests plotted in the correct location on the plot sheet?
 - v. Is the ▼ symbol used to denote the water table and are multiple tables dated for Non-Electronic ERS?

- vi. Are water table lines plotted?
- vii. Are lines drawn to clearly delineate phasing Non-Electronic ERS?
- viii. Are split LOTs and/or plot lines drawn to clearly delineate phasing for electronic ERS?

b. Density Record

- i. Is all header/sample information filled out correctly?
- ii. Do page numbers correspond to the referenced plot sheet Non-Electronic ERS and do FDOT Sample Numbers correspond to the appropriate LOTs for electronic ERS?
- iii. Is test data filled out correctly and completely?
- iv. Is there documentation when structure and pipe are compacted in the same operation?
- v. Are the graphs hand corrected or re-plotted when there is over-excavation or excavation of unsuitable material?
- vi. Is there a verification test for pipe (and structures if compacted separately) on each first lift not affected by water?
- vii. Are lifts affected by water denoted on the graph and density report sheet for Non-Electronic ERS?
- viii. Are both sides of the pipe tested on the first lift?
- ix. Is the same effort of compaction on successive lifts occurring on both sides of the pipe?
 - 1. If not, are density tests taken on both sides of the pipe?
- x. Is maximum compacted thickness kept to 6 inches in the cover zone?
- xi. Has a test section been tested and verified for any thick lift compaction outside the cover zone?
- xii. Do lines clearly delineate phasing and the transition from pipe backfill to embankment testing?

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- xiii. Are lifts compacted but not tested because of reduced frequency documented?
- 6) Does the LOT Index reflect the density testing to date (only applicable to Non-Electronic ERS)?
- a. Are special provisions and/or special requirements documented on the LOT index sheet and on other sheets where necessary?
- 7) Stabilizing Mixing Depth and Base Thickness
- a. Are mixing depths for subgrade recorded?
 - i. Are any measurements outside of the tolerance?
 1. If too deep did the inspectors dig down and test the bottom 12 inches?
 2. If too shallow did contractor remix the material?
 - b. Is depth of base recorded?
 - i. Are the QC measurements verified to be correct?