SECTION 31 43 13.13

JET GROUTING CUTOFF WALL

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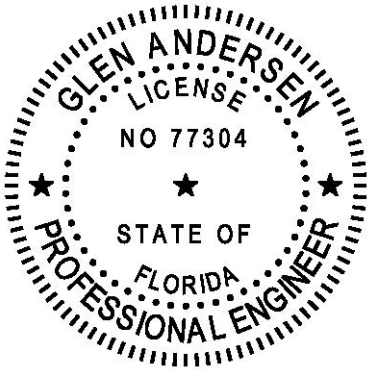

Digital Signature

DN: cn=Glen R. Andersen, o=Wood Environment & Infrastructure Solutions, Inc., ou, email=glen.andersen@woodplc.com, c=US
Date: 2021.07.28 17:47:53 -04'00'

GLEN ANDERSEN P.E., STATE OF FLORIDA, PROFESSIONAL ENGINEER, LICENSE NO. 77304.

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SECTION 31 43 13.13

JET GROUTING CUTOFF WALL

PART 1 GENERAL

1.1 SUMMARY

The work specified in this section consists of requirements for the construction of a Cutoff Wall, Tie-Ins and Support Columns using the Jet Grouting installation method. The Cutoff Wall, Tie-Ins and Support Columns will be constructed to the limits indicated in the drawings. This specification addresses the performance requirements to provide a finished Cutoff Wall.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

API RP 13B-1	Standard Procedure for Field Testing Water-Based Drilling Fluids
API Spec 13A	Drilling-Fluid Materials
ASTM D 4832	Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D 5084	Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

1.3 DEFINITIONS

The terms used in this Section are defined as follows:

A. Embankment: Earthen materials placed on the original or prepared natural ground surface for the construction of the Lake Manatee Reservoir Dam.

B. Foundation: The Foundation is considered to be all-natural soil and rock materials underlying the embankment.

C. Cutoff Wall: The Cutoff Wall is a wall created through the existing embankment to form a barrier with the required permeability and strength to cut off water flow.

D. Tie-Ins: Jet grout columns placed between seepage cutoff features such as the TRD wall or the soil-mixed columns to create a low permeability barrier.

E. Support Columns: Jet grout columns constructed immediately adjacent to and in direct contact with the stem of the downstream training walls for support of the structural seal slab.

F. Jet Grouting Installation Method: Jet grouting is an in-situ soil mixing technique used to construct cutoff walls. It employs hollow-stem drilling rods connected at their bottom to an injection monitor with horizontal radial nozzles delivering pressurized high velocity fluids to erode the in-situ soils and blend them with cementitious grout. The soil-cement material

produced by this method has significantly higher strength and lower permeability than the in-situ soils.

G. Single Fluid Jet Grouting: The jet grouting technique where a single fluid, typically neat cement grout, is injected at high velocity through horizontal radial nozzle(s) to directly erode and mix with the in-situ soil.

H. Monitor: A single, double, or triple fluid drill pipe attached to the end of a string of drilling rods and designed to deliver one to three elements of the Jet Grouting process, typically air, water, and grout. The monitor has one or more injection points (nozzles).

I. Soil-Cement: Mixture of grout slurry and in situ soils formed by the jet grouting process

1.4 PERFORMANCE REQUIREMENTS

A. Install monitor and test the Cutoff Wall, Tie-Ins, and Support Columns as identified in this specification within the limits indicated on the plans.

B. The Contractor shall be fully responsible for the means and methodology for the construction of the required Cutoff Wall, Tie-Ins, and Support Columns. In addition, the Contractor is fully responsible for the mix design of the jet grout materials and the selection of adequate jet grouting parameters, equipment and construction procedures to meet the stated performance criteria of the Cutoff Wall, Tie-Ins, and Support Columns. The completed Cutoff Wall, Tie-Ins, and Support Columns shall meet the performance criteria described below. Cutoff wall, Tie-Ins, and Support Columns acceptance measures are in the paragraph CUTOFF WALL, TIE-INS, AND SUPPORT COLUMNS ACCEPTANCE below.

1. Overlapping jet grouting columns/elements installed in a single or multiple rows must form a continuous Cutoff Wall AND Tie-In direct contact with each other or with the existing seepage cutoff feature with a minimum width of 30 inches.

2. Install support columns immediately adjacent to the retained earth side of the stem of the downstream training walls with a minimum column to column overlap width of 30 inches.

3. Construct the Cutoff Wall, Tie-Ins, and Support Columns to the depths indicated on the Plans.

4. The Cutoff Wall and Tie-Ins shall have an in-place permeability based on a 10-point running average of less than or equal to 1×10^{-6} cm/sec at 28 days.

5. The Cutoff Wall and Tie-Ins shall have a target unconfined compressive strength of 50 pounds per square inch or greater at 28 days.

6. The Support Columns shall have an unconfined compressive strength of 200 pounds per square inch or greater at 28 days.

7. The Cutoff Wall, Tie-Ins, and Support Columns shall be vertical. From a cross sectional view, they shall not lean in any direction by more than +- 2° from the vertical.

8. The soil-cement shall be shown to be chemically compatible with groundwater and soil conditions at the site and water used by the Contractor to construct the Cutoff Wall, Tie-Ins, and Support Columns.

1.5 SUBMITTALS

A. Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns Construction Plan

1) Submit a Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns Construction Plan describing the general work sequence and layout of operations a minimum of two days prior to commencing the work activity. Include the layout of operations with scale drawings, which depict the location of the batch plant, grout pump, storage, and staging areas. Describe equipment, grout mixing and pumping methods, work platform design and layout, jet grouting method, jet grouting element layout and installation pattern, spoil containment, disposal of spoils, and site clean-up.

2) Submit data on the equipment to be used in the construction of the Cutoff Wall, Tie-Ins, and Support Columns; equipment to be used to obtain samples; equipment to be used to obtain record control samples of the completed Cutoff Wall, Tie-Ins, and Support Columns; and equipment to be used in the Contractor's quality control testing.

3) The Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns Construction Plan must include a grout spoil return management plan outlining waste containment and cleanup methods during jet grouting and treatment and removal plans for jet grout spoil return.

4) Submit adjustments to the items included in this Plan during the construction of the Cutoff Wall, Tie-Ins, and Support Columns if any of the items are not performing in accordance with the performance requirements of this specification. These adjustments must be submitted and will not be allowed without written approval by the Engineer. The Owner reserves the right to require a test section to demonstrate that the adjustments will result in a Cutoff Wall, Tie-Ins, and Support Columns satisfying the performance criteria.

5) Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns Quality Control Plan must include the quality control testing program based on the Contractor's means and methods. The Contractor shall establish appropriate testing, acceptable quality control ranges, and testing frequency that is needed for approval by the Engineer. The plan shall include a description of quality control equipment and test procedures, acceptable parameters for the tests, sample test forms for reporting test results, and laboratories proposed for use.

B. Experience and Qualifications Requirements

1) Submit evidence of qualification through experience in the implementation of the jet grouting method for projects of similar size and nature.

C. Grout Mix Design

1) Submit a mix design for the project indicating sources and types of grout materials, with volumetric proportions, and test data from pre-construction soil-cement mix trials indicating set time and compressive strength achieved. The Contractor shall also submit the method for verifying the grout mix proportions.

1.6 QUALIFICATIONS

A. Project Experience

The Contractor must have at least five years jet grouting experience over the last ten years; and have completed at least five (5) jet grouting cutoff wall projects, with at least two (2) projects having objectives and methods similar to those of this project and in similar types of soils.

B. Personnel Experience

The jet grouting supervisor must have at least three (3) years on site experience managing Jet Grouting field operations of similar size and scope and must have supervised at least two (2) projects within the past five (5) years employing the technique proposed for this project. The supervisor shall have experience and knowledge of all aspects of Cutoff Wall, Tie-Ins, and Support Columns construction as required for the project and shall be present at the work site at all times during the jet grouting operations.

1.7 DELIVERY, STORAGE, AND HANDLING

Protect materials from weather, dirt, dust or other contaminants as described in the Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns Construction Plan.

1.8 DEMONSTRATION SECTION

A Demonstration Section is required to verify the means and methods are adequate to properly construct the Cutoff Wall as described.

A. Location

Submit the location of the Demonstration Section by the Contractor and approved by the Engineer. The Demonstration Section may be a part of the production wall.

B. Construction

The performance requirements of the Jet Grouting Cutoff Wall Demonstration Section are the same as the design requirements for the production Cutoff Wall and Tie-Ins. Include Demonstration Section design and construction procedures in the Jet Grouting Cutoff Wall Construction Plan.

C. Quality Control

1. Conduct quality control testing in accordance with the Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns Quality Control Plan. The performance of the Demonstration Section will be judged in accordance with the design requirements specified in paragraph PERFORMANCE REQUIREMENTS above and acceptance criteria in paragraph CUTOFF WALL, TIE-INS, AND SUPPORT COLUMNS ACCEPTANCE below.

2. Expose test elements by excavation (where possible) and measure geometric properties. If excavation is not feasible, drill samples or perform other testing methods to demonstrate column size/geometry. Coring in the center of the overlap area in a line of three elements (two locations) shall be carried out in accordance with Section 31 43 13.16 VERIFICATION DRILLING. At the direction of the Engineer, a borehole camera survey shall be completed as directed by the Engineer, and representative specimens from each core hole selected by the Engineer shall be sent to an independent laboratory for petrographic analysis. The bore hole shall be of sufficient size and quality to be able to accept inclinometer casing. All drilling and core sampling locations shall be repaired per the Engineer's recommendations.

3. The Engineer will allow the Contractor to proceed-at-risk with the proposed Jet Grout Cutoff Wall construction pending successful completion of all field and laboratory testing associated with the Demonstration Section. If the Demonstration Section does not pass the performance criteria, the Contractor will be required to revise the jet grouting method and/or mix design and install additional columns as necessary to meet the Cutoff Wall or Tie-Ins performance criteria.
4. The Cutoff Wall, Tie-Ins, and Support Columns Construction Plan must be finalized based on the successful performance of the Demonstration Section and used for the production Cutoff Wall, Tie-Ins, and Support Columns.

PART 2 PRODUCTS

2.1 MATERIALS

A. Water: Provide potable water or fresh water from an approved source free of deleterious substances that may adversely affect the properties of the grout. Water from the source to be used during the production of the Cutoff Wall, Tie-Ins, and Support Columns should be used for the testing program for the mix design.

B. Cement: Provide cement used in preparing the grout conforming to ASTM Designation C-150 “Standard Specifications for Portland Cement.” Protect the cement from moisture and contamination while in transit to and in storage at the job site. Do not use reclaimed cement or cement containing lumps or deleterious matter.

C. Bentonite, if used, must be pre-hydrated for at least 12 hours, unless demonstrated hydration is achieved in less time, prior to being incorporated in the mix.

D. The ratios of the material components shall be proposed by the Contractor, confirmed during the Demonstration Section, and reviewed by the Engineer. Once accepted, grout slurry composition shall not be changed unless requested in writing by the Contractor and accepted in writing by the Engineer.

2.2 EQUIPMENT

A. General: Furnish all necessary plants and equipment for use on this project. The equipment shall be in good operating condition and shall be capable of performing the work specified in the Contract. All equipment required for the Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns construction method shall be included in the Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns Construction Plan.

B. Specific Equipment Capabilities: Supply all equipment with the following minimum capabilities and characteristics:

1. Drilling Equipment: Furnish drilling equipment of a type and capacity suitable for drilling the required hole diameters and depths, and lowering, raising, and rotating jet grout monitors to the depths and at the rates required to produce a cutoff wall, Tie-Ins, and Support Columns conforming to the project plans and specifications. Equip drill rig with automated controls to regulate and maintain consistent rod retraction rate and rod RPM and have pressure gauges for all fluids injected.
2. Grout Mixing and Injection Equipment: Provide grout mixers and holding tanks, water tanks, air compressors, and pumps of sufficient capacity to ensure adequate supply of

grout, air, and water at required pressure to the jet grouting monitors during a full work shift to produce grout elements of the quality and dimensions necessary.

3. Jet Grouting Pump: Provide pump capable, with the nozzles proposed, of providing the required velocity and a delivery rate adequate for the execution of the work.
4. Jet Grout Tools: Uet grouting tools with appropriate nozzles with the capacity suitable for producing jet grout elements in the soil types identified during subsurface explorations performed at the site, and of the size and depth shown on the Construction Drawings and as specified herein. The drill hole diameter shall be sufficiently large to be a clear path for continuous spoil return during all jetting operations.
5. Equipment Instrumentation: The instrumentation must allow continuous monitoring and automatic recording of data throughout the jet grouting operations. As a minimum, the following shall be provided versus depth:
   i. Pressure gauges/devices at the drilling rig to automatically record pressures of cement grout, water, and air during the grouting process.
   ii. Flow meter(s) to monitor and record the rate and total volume of grouting fluids through the grouting monitor at every element.
   iii. Devices that automatically monitor and record the rate of monitor rotation and withdrawal.
6. Communication Equipment: An adequate communication system must be maintained between the jet grouting drilling rig operator and the batch plant operator.

PART 3 EXECUTION

3.1 SITE PREPARATION

A. Work Platforms: Design Work Platforms required to construct the Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns, to be suitable for the equipment and methodology proposed. Provide details of the work platforms in the Contractor's Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns Construction Plan.

B. Layout: Lay out Cutoff Wall alignment in the field in accordance with the Plans and Specifications.

3.2 JET GROUTING CUTOFF WALL, TIE-INS, AND SUPPORT COLUMNS

Production Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns: The production jet grouting must be executed using the same jet grout tooling, materials, and procedures used for the construction of the Demonstration Cutoff Wall Section. The jet grouting elements must be installed such that continuous spoil return up the borehole annulus is achieved during all work.

A. The centerline of the jet grouting elements must not be more than 3 inches from the indicated plan location.

B. The Cutoff Wall shall be vertical. From a cross sectional view, the Cutoff Wall must not lean more than +- 2° from vertical and shall be continuous with overlapping columns.

C. The sequence of the Jet-Grouting, Primary, and Secondary, fresh on fresh, pre-jetting with

water is the responsibility of the Contractor and must be based on the results of the successful Demonstration Section.

D. If jet-grouting is interrupted during the execution of an element, the re-start of the jetting shall be undertaken at least 3 feet below the stopping point.

3.3 QUALITY CONTROL

A. Monitoring and Logging: Monitoring and log jet grouting operations for both test areas and production work.

Configure jet grouting equipment to record and continuously show all fluid flows and pressures, rotational speed, depth, and rod retraction rates. The rod retraction rate and rod RPM shall be set by the driller then automatically controlled by the drill rig during the entire jet grouting process and recorded on the jet grout installation log.

Make all the data monitored and recorded available to the Engineer in a format established in the Jet Grouting Cutoff Wall, Tie-Ins, and Support Columns Construction Plan.

B. Grout Batching: Measure and document grout mix proportions in accordance with the Mix Design Report. Keep appropriate records and submit to the Engineer to verify that grout mixture(s) are as accepted.

C. Sampling and Testing of Soil-Cement Cutoff Wall, Tie-Ins, and Support Columns Material

Take two (2) bulk samples of the Cutoff Wall, Tie-Ins, and Support Columns Material at least once for every work shift. Take each sample randomly from different batches. The bulk samples shall be taken from the soil-cement spoils at intervals such as to be able to adequately characterize the full range in soil-cement mixing zones (some from high plasticity clay zones and others from sandy zones). Plastic molds used to cast the samples shall be 3 inch by 6 inch cylindrical test specimens. From each bulk sample, the Contractor shall cast at least six (6) test specimens for Quality Control purposes. The wet samples shall be poured into the molds and rodded or vibrated to remove trapped air pockets and then sealed. The specimens shall be stored in a constant temperature, damp environment until tested. The handling and storage requirements of the samples shall also be in accordance with ASTM D4832.

For each shift and for the Cutoff Wall and Tie-Ins one (1) of the test specimens shall be tested for hydraulic conductivity (permeability). For the Cutoff Wall, Tie-Ins, and Support Columns four (4) specimens shall be tested for unconfined compressive strength from a bulk sample representing a single batch. The remaining specimens from the same bulk sample shall be retained and properly stored for possible testing by the County. The six (6) specimens from the other bulk sample shall be retained by the Contractor for possible future testing.

1. Compressive Strength Testing: The four (4) sample test specimens from the randomly chosen bulk sample per shift shall be subjected to unconfined compressive strength tests in accordance with ASTM D 4832; one after curing for fourteen (14) days, and two after curing for twenty-eight (28) days, and one after curing for fifty-six (56) days.

2. Permeability Testing: One (1) sample test specimen from the randomly chosen bulk sample per shift per heading shall be subjected to laboratory permeability testing after curing for seven (7) days. The permeability tests shall be performed in accordance with

ASTM D 5084, Method A. The permeameter cell shall be sized to accommodate a minimum 3-inch-tall sample. Sample trimming shall be conducted in such a manner as to minimize the potential of sample disturbance. The permeability test parameters shall be as follows:

- Average Effective Confining Stress: 10 psi
- Hydraulic Gradient: 15
- Permeate: Lake Manatee water collected adjacent to the construction site
- Backpressure: Sufficient to ensure a Skempton's pore pressure "B" parameter greater than or equal to 0.95

The test shall be continued until inflow-outflow measurements or flow rates demonstrate that steady state seepage conditions are present.

3.4 CUTOFF WALL, TIE-INS, AND SUPPORT COLUMNS ACCEPTANCE

The Cutoff Wall, Tie-Ins, and Support Columns will be accepted after successfully achieving the performance requirements indicated in the paragraph PERFORMANCE REQUIREMENTS above as demonstrated below.

A. Cutoff Wall, Tie-Ins, and Support Columns continuity and homogeneity shall be as demonstrated from the cores, photographs, and logs taken in accordance with Section 10 VERIFICATION DRILLING.

B. Cutoff Wall, Tie-Ins, and Support Columns depth shall be verified from Quality Control Monitoring Records.

C. Cutoff Wall and Tie-Ins permeability shall be demonstrated by the laboratory permeability testing described in QUALITY CONTROL above. The 28-day permeability shall be less than or equal to $1x10^{-6}$ cm/sec with a 10-point moving average and in not to exceed 10^{-5} cm/sec on any one sample.

D. Cutoff Wall and Tie-Ins strength shall be demonstrated by the laboratory 28-day UCS described in QUALITY CONTROL above. Samples should yield a target compressive strength of 50 pounds per square inch when tested in accordance with ASTM D 2166.

E. Support Columns strength shall be demonstrated by the laboratory 28-day UCS described in QUALITY CONTROL above. Samples should yield a target compressive strength of 200 pounds per square inch when tested in accordance with ASTM D 2166.

F. Document Cutoff Wall, and Tie-Ins verticality by recording pull rates and injection pressures and through a minimum of four cores taken at the intersection between the two production columns and in accordance with Section 31 43 13.16 VERIFICATION DRILLING. These core locations will be determined by the Owner’s Engineer. Where directed by the Engineer, conduct a borehole camera survey and/or install an inclinometer in the core hole. Send representative specimens selected by the Engineer to an independent laboratory for petrographic analysis to satisfy the criteria specified in the CUTOFF WALL, TIE-INS, AND SUPPORT COLUMNS ACCEPTANCE below. Create core holes, and install the inclinometer casing, and making inclinometer measurements as directed by the Engineer. Grout the core holes and inclinometer casing where installed.

G. Should testing reveal a failure of any portion of the Cutoff Wall, Tie-Ins, or Support Columns to meet the requirements above, a section of the Cutoff Wall, Tie-Ins, or Support Columns as determined by the Engineer will be replaced at no expense to the Owner. At a minimum, the section of the Cutoff Wall, Tie-Ins, or Support Columns between the locations of the two nearest passing tests shall be replaced. The Contractor may perform additional testing at no additional cost to the Owner to reduce the extent of the segment to be replaced, when approved by the Engineer.

3.5 TREATMENT OF TOP OF CUTOFF WALL

Jet grout columns will be stopped 5 ft below grade and the remaining bore hole will be backfilled with neat cement grout to the required grades in accordance with the Plans.

3.6 CLEAN-UP

The Contractor shall continually clean up waste, debris, and leftover materials resulting from the Cutoff Wall, Tie-Ins, or Support Columns construction process. These materials shall be disposed of in designated areas provided by the Owner in accordance with all Federal, State, and local regulations and codes.

-- End of Section --