



**SECTION 31 50 00**  
**SECANT PILE WALL**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Furnish all plant, labor, equipment, appliances and materials and perform all operations for the construction of a 24-inch thick soil-cement or soil-cement-bentonite secant pile wall, as indicated on the Drawings and specified in this Section, including, but not limited to the following:
1. Works shall be directed by a licensed Geotechnical Engineer.
  2. Installation of the secant pile wall along the perimeter of the flood wall in accordance with the criteria provided herein and good engineering practice.
  3. The secant pile wall shall consist of a continuous line of drilled shafts with overlapping adjacent shafts.
  4. Provide approved vibration isolation material as required against existing footings, pile caps, foundation walls, structures, manholes, utility ducts, etc. wherever the secant pile wall or guide walls are poured in contact with these existing structures.
  5. Pretrench along the secant pile wall alignment to expose and remove rubble, miscellaneous fill, abandoned utilities, obsolete foundations, timber piles or other material which would obstruct the normal installation procedures.
  6. For the secant pile wall, backfill the pretrench to a level surface at least up to the bottom of the guide walls, if used, with flowable fill, lean concrete, or approved equivalent. Construct concrete guide walls as required to accommodate the proposed construction.
  7. Regrade the existing ground surface as required to facilitate the construction of the secant pile wall and possible guide walls. Grade shall be left at the elevation of the top of Auger Cast Pile/Secant Pile Wall to ensure the integrity of the pile tops prior to excavation of the footing.
  8. Provide temporary drill casing and drilling fluid, as necessary, to maintain stability of the drill hole and prevent any loss of ground due to the secant pile installation.



9. Legally haul and dispose of drill spoil material at an approved unlined landfill as Group I-4 material. Pretrench material for removal of obstructions shall also be removed from the site.
10. Furnish and install drill hole, soil-cement, soil-cement-bentonite and other permanent items shown on the Drawings.
11. Construct the secant pile wall to the specified tolerances.
12. Clean off and leave top of secant pile wall in clean, neat condition to permit continuation of the wall. Remove all contaminated or soil-cement from the top and inside of the wall to sound material. Pile tops shall extend a minimum of 228 mm (9 inches) into the flood wall footing and be in intimate contact with the footing concrete.
13. Provide qualified supervision, by licensed Geotechnical Engineer or his designee for secant pile wall work to monitor alignment of the wall excavation, maintain records on soil stratigraphy, note any problems during excavation, and monitor soil-cement or soil-cement-bentonite mixing operations.
14. Provide adequate and continuous support of structures, streets, utilities, sidewalks and other facilities in the vicinity of the drill hole to protect such facilities against damaging movements or effects.
15. Provide vibration mitigation plan, outline measures to reduce construction vibrations if peak particle velocities exceed 0.30 in/sec at the ground surface.
16. Provide vibration monitoring equipment for use adjacent to construction areas. Work stoppage required if peak particle velocity exceeds 0.30 in/sec at the ground surface, resident engineer shall determine when work shall resume. Vibration mitigation plan shall be instituted if peak particle velocities exceed 0.30 in/sec at the ground surface.
17. Specific details regarding the use of Deep Soil Mixing (DSM) or Deep Mixing Method (DMM) to create the secant pile wall using soil-cement (SC) or soil-cement-bentonite (SCB) is specified Section 31 56 17, DEEP SOIL MIXING.

## **1.2 RELATED WORK**

- A. Examine Contract Documents for requirements that affect work of this Section. Other specification Sections that directly relate to work of this Section include, but are not limited to:



1. Conditions of the Contract; Authority and responsibilities of the Contractor.
2. Section 31 20 00, EARTH MOVING.
3. Section 03 30 00, CAST-IN-PLACE CONCRETE.
4. Section 31 56 17, DEEP SOIL MIXING.
5. Section 31 63 16, AUGER CAST PILES.

### **1.3 COORDINATION**

- A. Coordinate work with that of other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

### **1.4 DEFINITIONS AND REFERENCE STANDARDS**

- A. ASTM: Specifications of the American Society for Testing and Materials.
- B. API: American Petroleum Institute Standard 13A, 1969 and Report 13B, 1972.
- C. ACI: American Concrete Institute.

### **1.5 INSTALLATION CRITERIA**

- A. A primary function of the secant pile wall is to serve as a seepage lengthening measure to reduce the inflow of water through the fill materials encountered below the flood wall.
- B. The secant pile wall shall be installed to a depth of 20 feet below the bottom of the flood wall footing as shown in the design drawings, and as directed by the Engineer. Trenching may be considered as an alternative to the secant pile wall where rock is encountered within the 1524 mm (5 feet) of the bottom of the floodwall footing, refer to the project geotechnical report for locations where this condition could be anticipated.
- C. Low-overhead equipment will be required for the installation of the secant piles along a portion of the floodwall alignment.
- D. The secant pile wall shall consist of overlapping drilled soil-cement or soil-cement-bentonite shafts constructed by high torque rotary drilling equipment.
- E. The secant pile wall or DMM wall shall be installed in four phases. The initial phase shall include the installation of primary piles spaced as indicated on the drawings in two passes. The initial pass will install every other primary pile while a subsequent pass (minimum of 24 hours after the initial pass) will install the remaining primary piles. Secondary piles shall be installed within 48 hours of installing any subsequent primary pile.



Secondary piles shall be installed between the primary piles and secant (i.e., overlap) the primary piles. The secondary piles will follow the procedure used to install the primary piles in that there will be two passes, the first will install every other (non-adjacent) secondary piles and the second pass will install the remaining secondary piles, with the second pass a minimum of 24 hours after the initial pass. The secondary piles shall be completed within 72 hours of the installation of the primary piles. The minimum amount of overlap (interlock) between adjacent piles shall not be less than 6 inches.

- F. Grade differences between the bottoms of adjacent secant piles shall be limited to 1.0 feet, unless otherwise accepted by the Engineer to accommodate field conditions.
- G. The top of the secant piles shall be constructed to the elevations shown on the Drawings. Higher or lower elevations may be utilized only with the acceptance of the Engineer.
- H. The Contractor's attention is directed to the possibility that loss-of-ground resulting from installation of the secant piles through the natural granular deposits located below the groundwater level may cause damage to existing nearby buildings, utilities, etc., and shall be controlled to avoid such damage. Therefore, methods used to advance the drill hole through the saturated natural granular deposit shall be controlled in such a way so as not to cause damaging loss-of-ground. Such methods may include: pre-treatment (i.e. grouting) of the natural granular deposit, temporary casing, drilling fluid and maintaining a head of water within the casing during drilling operations. The Contractor shall use appropriate equipment and construction procedures to eliminate any loss-of-ground during the drilling operations.
- I. The Contractor's attention is directed to the possibility that vibrations resulting from installation of the secant piles may cause damage to existing nearby buildings, utilities, etc., and shall be kept to a minimum to avoid such damage. Therefore, methods used to advance the drill hole through boulders shall be controlled in such a way so as not to cause damaging vibrations. The Owner will monitor vibrations caused during the secant pile installation operations. The Contractor shall use appropriate equipment and construction procedures to limit the peak vibration velocity to a maximum of 0.30 inch per second as measured



at the ground surface immediately adjacent to the secant pile installation operations and within the adjacent building structures.

- J. The Contractor's attention is directed to the existing structures which are present along portions of the excavation perimeter.
- K. The intent of this specification is to provide a secant pile wall that lengthens the seepage path to reduce the hydraulic gradients and flow into the protected area inside the flood wall.
- L. These criteria are intended to establish a minimum basis for the Contractor's installation procedures and in no way relieve the Contractor of his sole responsibility for preventing detrimental movements and damage to adjacent structures, utilities or other work.

#### **1.6 SUBMITTALS**

- A. Mix Design, Equipment and Materials:
  - 1. Soil-cement or soil-cement-bentonite mix designs and supplies, as required in the Contract Documents.
  - 2. Provide stress-strain curves and Modulus of Elasticity with mix designs.
  - 3. Description of all equipment to be used for construction of the secant pile wall, including space requirements for operations and storage of materials.
- B. Other Items: Specific installation items shall include the following:
  - 1. Proposed method of continuous monitoring for plumbness and deviation of secant piles from the wall alignment during drilling of the piles, and details of corrective measures to be implemented as required.
  - 2. Proposed method of maintaining drill hole stability during advancement of the secant pile through the natural granular soil deposits located below the groundwater level.
  - 3. Complete details of locations and extent of vibration isolation material installed between existing structures or utilities and elements of the secant pile wall (including guide wall).
  - 4. The Contractor shall submit the means and methods for removal of the existing obstructions within the alignment of the secant pile wall so as to minimize settlement and or vibration of adjacent structures.
  - 5. A vibration mitigation plan that outlines measures to minimize vibration during drilling and construction operations shall be submitted 14 days prior to commencement of work.
- C. Project Records:



1. During secant pile wall installation, the Contractor shall maintain and submit to the Engineer as-built records, signed by a licensed civil engineer, of the work, as applicable including:
    - a. Pile identification.
    - b. Plan dimensions and vertical alignment of the secant pile and elevations of guide walls, and top and bottom elevations of the piles.
    - c. Dates and times of pile drilling and volume of bentonite and cement slurry placed.
    - d. Description and location of soils encountered, obstructions, and excavation problems, if any.
    - e. Description of steel reinforcing, cut-outs, threaded inserts, and sleeves, and bearing plates; variations from shop drawings, if any.
    - f. Details of geotechnical instrumentation installed in pile, if any.
    - g. Plumbness and deviation from plan location.
  2. During secant pile wall construction, any unusual conditions encountered shall be noted and the Engineer shall be informed as soon as possible.
- D. All submittals shall be made to the Engineer. The time period(s) for submittals are the minimum required by the Engineer to review, evaluate and respond to the Contractor. If, after review, the Engineer requires re-submission for any reason, the specified time period(s) shall commence upon the date of receipt of the re-submittals. The Contractor is responsible for scheduling specified submittals and re-submittals so as to prevent delays in the work.

#### **1.7 DELIVERY, STORAGE AND HANDLING**

- A. The secant pile wall is to be constructed in an urban area which has heavy traffic of vehicles and pedestrians. Stockpile materials and install plant only in indicated staging areas within the property limits. Keep public ways and areas clean and clear of all spillages from construction operations and from trucks hauling materials to or from the project site.
- B. Do not stockpile any materials of any kind behind the secant pile wall that could adversely affect the wall system and/or the overall wall stability.



- C. Take special care in promptly and legally disposing of material from the work area, including all drill spoils. Disposal of drill spoils on-site or in the sewer system shall not be permitted. No temporary collecting ponds or lagoons shall be allowed.

#### **1.8 JOB CONDITIONS**

- A. Subsurface information, including the logs of borings and test pits performed at the site, has been collected for this project and is available at the office of the Resident Engineer.
- B. The aforementioned borings were prepared for purposes of foundation and cut-off wall design only. These data are offered for general information only. No claim for extra compensation or extension of time will be allowed on account of subsurface conditions inconsistent with the data given, except as otherwise provided elsewhere herein. Interpretation of this data for purposes of construction is the responsibility of the Contractor. It is the Contractor's sole responsibility to make interpretations and draw conclusions with respect to the character of the materials to be encountered and their impact upon his work based on his expert knowledge. Neither the Owner nor the Engineer assumes responsibility for the accuracy of the data.
- C. The Contractor shall examine the site, the Drawings, survey of existing utilities, and the records of test borings and test pits.
- D. Plans, surveys, measurements, and dimensions under which the Work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period. The Contractor shall report any discrepancies noted in the above documents to the Engineer without delay.
- E. Support and protect utilities if and as necessary. The Contractor shall be responsible for all damages to utilities caused by secant pile wall construction operations. Fully and promptly repair and/or restore all utilities which are damaged at no expense to the Owner or the Utility Owner.
- F. The project site has been occupied by several previously demolished structures. Therefore, the Contractor shall expect encountering remnants of old foundations, walls, footings, etc., during secant pile wall installation.



## **1.9 QUALITY CONTROL**

- A. The Contractor shall provide evidence that he has at least five (5) years of experience with work comparable to the Work shown and specified, and in similar subsurface conditions, employing labor and supervisory personnel who are experienced in this type of Work.
- B. Adhere to the applicable requirements of the standard specifications, OSHA Standards and interpretations Subpart P-Excavations, Trenching and Shoring, and to all other applicable ordinances, codes, statutory rules and regulations of the Federal, State and local authorities.
- C. Quality control and field inspection shall be provided by the Contractor as follows:
  - 1. The Contractor shall provide personnel, qualified by training and experience, to perform the required tests and to monitor, record, plot and report the data. In addition, the Geotechnical Engineer will be present for selected installation and shall be allowed unrestricted access.
  - 2. The Contractor shall be responsible for making prompt and continuous evaluations of the secant pile installation and, whenever necessary, taking immediate steps to correct any deficiencies or to provide other corrective measures which may be required to prevent damage or excessive movements.
- D. At 100 foot intervals, three (3) representative bulk samples of the cutoff wall material shall be obtained at each of the following depth ranges: Obtain samples between a depth range of 0 to 10 feet (upper zone), and within 10 feet of the bottom of the cutoff wall (bottom zone). The bulk samples shall be taken at depth as indicated using a discrete wet bulk sampling method. 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 four (4) test specimens. Gravel and other particle sizes greater than 3/4 inch diameter shall be removed and discarded from cylinder samples.
  - 1. The wet samples shall be poured into the molds 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 be in accordance with ASTM D4832.
  - 2. For each bulk sample collection, half of the test specimens shall be tested for hydraulic conductivity (permeability) (28-day) and half



shall be tested for unconfined compressive strength (28-day) from a bulk sample representing a single batch.

E. Sample Collection and Testing:

1. Wet bulk sampling and testing by the Contractor, will be required as indicated below.
2. Acceptance of the work will depend on the Contractor's work demonstrating that the in-place wall is homogeneous, continuous, and has achieved the permeability and strength requirements. Quality Assurance sample collection and testing, in addition to the testing required by the Contractor, will be conducted by the a laboratory that the Owner will select. Samples shall be collected using: (1) discrete wet bulk sampling at frequencies described below, and (2) other sampling methods as required to obtain representative samples of construction materials. Results of tests performed on wet bulk samples shall take precedence over results of other sampling methods.
3. Wet Bulk Sampling:
  - a. Wet bulk material shall be sampled and test cylinders prepared per ASTM D 4832, with the following exceptions. Each cylinder shall be 3 inches in diameter and 6 inches in length. The wet bulk sample shall be taken using a discrete wet bulk sampling method that allows for complete retrieval of the mixed material without additional mixing or segregation. Three (3) representative bulk samples of the cutoff wall material shall be obtained at each of the following depth ranges: Obtain samples between a depth range of 0 to 10 feet (upper zone), and within 10 feet of the bottom of the cutoff wall (bottom zone).
  - b. The retrieved sample shall be passed through a 3/4-inch sieve prior to cylinder fabrication; no other sieving is allowed. After the sample is retrieved from the wall additional mixing of the sample is prohibited. At a minimum, the Contractor shall perform a 28-day unconfined compressive strength and a permeability test for each sample for the acceptance. For each wet bulk sample collected, the Contractor shall cast a minimum of four (4) cylinders.
  - c. Approximately up to 10 percent of the tested locations will be selected for quality assurance testing by the Government. At



these selected locations, the Contractor shall obtain and provide to the Agency a set of eight (8) representative cylinders for quality assurance testing.

4. Wet Bulk Sample Permeability Testing:

- a. Laboratory permeability testing shall be in accordance with ASTM D 5084. For permeability testing, the cell and backpressure states to be applied during the initial application to achieve 10 psi effective confining pressure which produce a B coefficient equal to or greater than 0.9. In no case shall the cell pressure exceed 100 psi.

| STAGE | CELL<br>BACK PRESSURE<br>(psi) | EFFECTIVE<br>PRESSURE<br>(psi) | CONFINING<br>PRESSURE<br>(psi) |
|-------|--------------------------------|--------------------------------|--------------------------------|
| 1     | 5                              | 3                              | 2                              |
| 2     | 10                             | 8                              | 2                              |
| 3     | 20                             | 15                             | 5                              |
| 4     | 30                             | 20                             | 10                             |
| 5     | 40                             | 30                             | 10                             |
| 6     | 60                             | 50                             | 10                             |

- b. Saturation shall be confirmed by measuring the B coefficient. The initial gradient used during permeation shall be 20. Plots of the ratio inflow to outflow, gradient, and permeability versus time shall be required for each test. Lines describing the boundary limits for the listed termination criteria shall be included on the plots. The permeate liquid shall be clean water. The specimen top cap, bottom cap, and porous end pieces shall have a diameter equal to the diameter of the test specimen  $\pm 2\%$ . Head shall be increased on the inflow end at the bottom of the specimen to a pressure which will develop the gradient of 20.

5. Wet Bulk Sample Strength Testing: Laboratory strength testing shall be in accordance with ASTM D4832.

- a. Minimum compressive strength of 100 psi at 14 days and 150 psi at 28 days. The maximum strength of the mix shall be less than 300 psi at 28 days.

F. Full-time monitoring of secant pile installations will be provided by the Geotechnical Engineer or his representative. No piles shall be



installed except in the presence of the Geotechnical Engineer or his representative.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS**

- A. Soil-Cement or soil-cement-bentonite for use in secant pile walls shall have:
1. Minimum compressive strength of 100 psi at 14 days and 150 psi at 28 days. The maximum strength of the mix shall be 300 psi at 28 days.
  2. The Contractor shall submit his proposed soil-cement or soil-cement-bentonite mix design to the Engineer for review a minimum of 30 days prior to commencement of work.
  3. Soil-cement or soil-cement-bentonite mix design shall allow the installation of auger cast drilled piles through completed secant piles or DMM wall.

### **2.2 EQUIPMENT**

- A. Secant piles shall be installed with high-torque rotary drilling equipment as approved by the Engineer. Equipment shall be suitable for the proposed work, and of a design, size and capacity to effectively perform the work.
- B. The Contractor shall provide at least two fully equipped rigs with crew in full-time operation at the site during the work, and shall mobilize additional equipment, if necessary, to complete the work on schedule.

## **PART 3 - EXECUTION**

### **3.1 GENERAL REQUIREMENTS**

- A. Preparatory work such as removal of existing foundations and other obstructions in the vicinity of the secant pile walls during pretrenching along the wall alignment shall be performed by the Contractor. The Contractor is hereby notified that existing foundations may be present along portions of the secant pile wall alignment. The Contractor shall remove the existing obstructions within the alignment of the wall in such a manner as to minimize settlement or settlement potential of the existing adjacent structures.
- B. Placement of flowable fill or lean concrete in the pretrench area for support of the guide walls shall be performed by the Contractor.



- C. Excavation for and construction of the secant pile wall shall be performed between two scalloped, reinforced concrete guide walls constructed along the entire alignment of the wall. The top of the guide walls shall be compatible with excavating and constructing the secant pile walls to the top wall elevations indicated on the Drawings. Regrade existing site grades, as required, for the construction of guide walls. Guide walls will be constructed such that the structural Auger Cast Piles (ACP) can be installed following construction of the secant pile wall
- D. Employ construction methods and protective coverings which prevent the leakage or spillage of drill spoils, soil-cement, or soil-cement-bentonite into utilities, streets, sidewalks, or other facilities.
- E. Along the entire length of the secant pile walls, the walls shall be advanced a minimum of twenty (20) feet below bottom of the flood wall footing and as directed by the Engineer unless bedrock is encountered at depths shallower than twenty (20) feet, in which case the secant pile wall may terminate at bedrock. Trenching may be considered as an alternative to the secant pile wall where rock is encountered within the 5 feet of the bottom of the floodwall footing, refer to the project geotechnical report for locations where this condition could be anticipated.
- F. Take all necessary measures to prevent collapse of the drill hole prior to concreting.
- G. Piles/DMM wall shall be constructed in the sequence outlined in Article 1.5 paragraph E.

### **3.2 DRILLING METHODS**

- A. Drilling equipment shall be capable of advancing through all pretrench fill and soil required for excavation of the secant pile wall. Flight augers, bucket augers, or other methods acceptable to the Engineer shall be used. Temporary casing may be used to stabilize the drill hole for the full depth of the pile.
- B. Drilling in a given pile shall proceed continuously from ground surface to the required depth. Each pile shall have the minimum diameter shown on the Drawings for the full length of the pile. Piles shall be drilled to a flat bottom at the same elevation. The drill hole bottom shall be cleaned free of all loose soil and rock particles using methods acceptable to the Geotechnical Engineer.



- C. Drill spoils shall be removed from within the temporary casing.  
Internal flush methods shall be used and wash water return shall be within the casing. External flush will not be permitted. The drill bit shall not extend closer than one foot above the casing bottom.
- D. As soon as required depth is first reached, the Contractor shall notify the Geotechnical Engineer who will determine the actual depth at which the secant pile will be terminated.
- E. If any secant pile has been started before the end of any day, the work on that pile shall be continued until drilling and soil-mixing has been completed on that same day at no additional cost.
- F. During drilling of the secant piles, the Contractor shall provide positive protection against the entrance of groundwater, cave-in, and displacement or loss of surrounding ground into or adjacent to the piles by the use of temporary steel liners or casings. The liners or casings shall be of a diameter large enough to ensure the minimum required pile diameter and shall be of sufficient strength to resist earth and groundwater pressures without distortion.
- G. Secant pile installation adjacent to and around existing structures and utilities which are to remain in place shall be performed without causing damage to, or movement of same, and without movement or loss of ground.
- H. Vibration monitoring equipment shall be placed no more than 3 feet from the property line on a line perpendicular to the floodwall alignment that passes through the auger location.
- I. Material removed from the secant piles shall be disposed of off-site in accordance with Sections 01 00 00, GENERAL REQUIREMENTS and 01 74 19, CONSTRUCTION WASTE MANAGEMENT.

### **3.3 OBSTRUCTIONS**

If, while excavating for piles, the Contractor encounters an obstruction, he shall notify the Engineer immediately. Obstructions shall be defined as boulders, granite blocks, concrete, wood piles, or other material which require more than one (1) hour of continuous effort by the Contractor to remove. The Contractor shall be reimbursed for additional work of removing obstructions. Payment for additional work required to penetrate, bypass or remove obstructions as defined above shall be made in accordance with Section 01 20 00 UNIT PRICES.



### **3.4 DEEP SOIL MIXING**

Specified in Section 31 56 17, DEEP SOIL MIXING.

### **3.5 PERFORMANCE REQUIREMENTS AND TOLERANCES**

- A. Secant pile wall shall be constructed entirely within the lateral limits indicated on the Contract Drawings. No portion of the wall designed to remain in place shall penetrate beyond the tolerances established below. Any bulges, portions of piles which are revealed during excavation to extend beyond the tolerances shall be removed at no extra cost.
- B. Secant pile wall construction shall be controlled by the following tolerances:
  - 1. The overall out-of-plumb tolerance from the designed vertical plane for the entire wall centerline from top to bottom shall not exceed one (1) percent of the height at any point in the wall.
  - 2. Soil-cement or soil-cement-bentonite shall be shown to have a hydraulic conductivity (permeability) of less than  $1 \times 10^{-6}$  cm/sec through the use of testing of proposed mix designs prior to installation of secant pile wall and through use of testing as described in the Article QUALITY CONTROL.

### **3.6 PAYMENT**

- A. Payment shall be made on the basis of the Base Bid for the work shown on the Drawings and specified herein, as a lump sum.
- B. Payment will be made for removing, bypassing or penetrating obstructions as defined in Article OBSTRUCTIONS on a unit price basis.

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