SECTION 31 62 16.13

STEEL PIPE PILES

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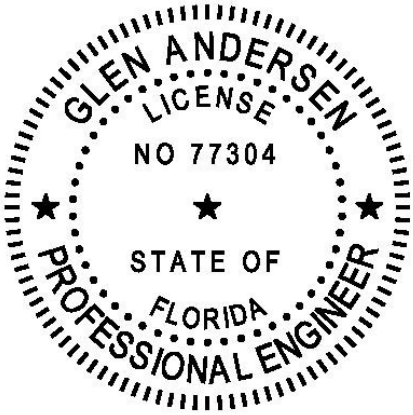

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GLEN ANDERSEN P.E., STATE OF FLORIDA, PROFESSIONAL ENGINEER, LICENSE NO. 77304.

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SECTION 31 62 16.13

STEEL PIPE PILES

PART 1 GENERAL

1.1 DESCRIPTION

Design, furnish, install and test steel pipe piles at the locations indicated on the drawings and specified herein. Assume test pile(s) will be directed to be placed in a location(s) that can be incorporated into the work.

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.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel
AWS D1.5M/D1.5	(2020) Bridge Welding Code

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A109/A109M	(2016; R 2018) Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled
ASTM A148/A148M	(2020; E 2020) Standard Specification for Steel Castings, High Strength, for Structural Purposes
ASTM A252	(2010) Standard Specification for Welded and Seamless Steel Pipe Piles
ASTM A572/A572M	(2018) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A972/A972M	(2015) Standard Specification for Fusion Bonded Epoxy-Coated Pipe Piles
ASTM D1143/D1143M	(2007; R 2013) Piles Under Static Axial Compressive Load

ASTM D3689	(2007; E 2013; R 2013) Standard Test Methods for Deep Foundations Under Static Axial Tensile Load
ASTM D3966/D3966M	(2007; R 2013; E 2013) Standard Test Methods for Deep Foundations Under Lateral Load
ASTM D4945	(2017) Standard Test Method for High-Strain Dynamic Testing of Deep Foundations
ASTM E94/E94M	(2017) Standard Guide for Radiographic Examination Using Industrial Radiographic Film
ASTM E164	(2019) Standard Practice for Contact Ultrasonic Testing of Weldments
ASTM E165/E165M	(2018) Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E329	(2020) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
ASTM E709	(2015) Standard Guide for Magnetic Particle Examination

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1	(2016) Shop, Field, and Maintenance Coating of Metals

FLORIDA DEPARTMENT OF TRANSPORTATION DIVISION 1 AND 2	(2021) STANDARD SPECIFICATIONS

1.3 SUBSURFACE DATA

Subsurface soil data logs are provided on the project bid attachments.

1.4 BASIS OF BID

1.4.1 Contractor's Geotechnical Consultant

Hire the services of an independent, Registered Professional Geotechnical Engineer, experienced in soil mechanics and Pile Dynamic Analysis, to observe test pile installation as specified herein. The Contractor's Geotechnical Consultant must be independent of the Contractor and must have no employee or employer relationship, which could constitute a conflict of interest.

1.4.2 Production Pile Acceptance Criteria

Drive piles to the minimum tip elevation as indicated on the plans.

1.5 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Installation Procedures
Contractor's Geotechnical Consultant Qualification
Testing Agency Qualifications
Vibration and Monitoring Plan
Instrumentation and Monitoring Consultant Qualifications
Instrumentation and Monitoring Program Reports
Remediation Plan

SD-02 Shop Drawings

Piles
Pile Splices
Pile Placement
As-Driven Survey
Pile Load Test
Pile Shoes

SD-03 Product Data

Pile Driving Equipment
Pile Test
Manufacturer Installed Sealant Along the Interlock for Sheet Pile Connection
Coating System to be Installed on Portions of Pipe Pile Permanently Exposed to the Elements

SD-05 Design Data

Procedure for Insufficient Pile Tip Elevation

SD-06 Test Reports

Test Piles
Load Tests
Dynamic Pile Analysis
Wave Equation Analysis

SD-07 Certificates

Pile Shoes
Pile Splices
Welder Certification
Steel Plant Certification

Pile Material Test Report

SD-11 Closeout Submittals

Pile Records with Tip Elevations

1.6 DELIVERY, STORAGE, AND HANDLING

Conform all delivery, storage, and handling of materials to the requirements specified herein.

1.6.1 Delivery and Storage

Stack piles during delivery and storage so that each pile is maintained in a straight position and is supported every 10 feet or less along its length (ends inclusive). Do not stack piles more than 5 feet high.

1.6.2 Handling

Lift piles to ensure that the maximum permissible curvature is not exceeded. Holes may be burned above the cutoff length for lifting piles into the leads. If there is evidence of pile damage during driving due to the holes, Owner's Representative may forbid the burning of holes. Do not damage piles when dragging piles across the ground or barge deck.

Inspect piles for excessive curvature and for damage before transporting them from the storage area to the driving area and immediately prior to placement in the driving leads. Curvature in the pile must be measured with the pile laying on a flat surface and in the distance between the pile at the mid-length of the pile and the flat surface. Straightness of the sections of steel pipe piles must conform to AWS D1.5M/D1.5, Section 3.5.1.1. Piles having excessive curvature will be rejected.

1.6.3 Damaged Piles

Inspect each pile for straightness, structural and coating damage before transporting them to the project site and immediately prior to placement in the driving leads. Bring any damage to the attention of the Engineer of Record. Piles which are damaged during delivery, storage, or handling to the extent they are rendered unsuitable for the work, in the opinion of the Engineer of Record, will be rejected and removed from the project site, or may be repaired, if approved, at no cost to the Owner.

Any pile damaged by reason of internal defects or by improper driving must be corrected by one of the following methods approved by the Engineer for the pile in question:

a. The pile is withdrawn, if practicable, and replaced by a new and, if necessary, longer pile.

b. One or more replacement piles are driven adjacent to the defective pile.

c. A Pile Dynamic Analysis and low integrity testing must be performed by the Contractor's Geotechnical Consultant to assess the structural integrity and continuity of the driven pile(s).

A pile driven below the specified butt elevation must be corrected by one of the following methods approved by the Engineer:

a. The pile is spliced (if approved).

A pile driven out of its proper location or out of plumb as approved by the Engineer, must be corrected as follows:

b. Submit alternative method to be approved by the Engineer.

1.7 QUALITY CONTROL

1.7.1 Piles

Prepare and submit shop drawings for piles. Indicate placement of piles. Indicate location of special embedded or attached lifting devices, employment of pick-up points, support points other than pick-up points, and any other methods of pick-up. Perform quality control testing of the concrete infill in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

1.7.2 Quality Control Procedures

Submit the pile manufacturer's quality control procedures.

1.7.3 Installation Procedures

a. Submit information on the type of equipment proposed to be used, proposed methods of operation, method of confirming that the appropriate tip elevation has been reached, pile driving plan including proposed sequence of driving, and details of all pile driving equipment and accessories. Submit descriptions of pile driving equipment, including hammers, power packs, driving helmets, hammer cushions, pile cushions, leads, extractors, and preboring equipment at least 30 days prior to commencement of work.

b. Provide details of pile driving equipment and a Wave Equation Analysis of pile drivability for selection of the hammer along with a statement of driving procedures. Provide instructions and procedures on how the Contractor will perform Dynamic Pile Testing, Inspection and Monitoring of piles during installation and testing. The Wave Equation Analysis is to be completed by the Contractor's Geotechnical Consultant for each test pile location where different subsurface conditions exist and is to include the following information pertaining to the proposed pile driving equipment:

(1) Complete Pile and Driving Equipment Data Form, (which can be downloaded at: https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables) for each proposed pile hammer and pile type combination.

(2) Copies of computer input and output sheets and graphs showing soil resistance versus blow count as well as maximum tension and compression stresses versus blow count. Analysis must be run at the estimated tip elevation as well as other required elevations to define maximum stress levels in the pile during driving.

PART 2 PRODUCTS

2.1 PILE REQUIREMENTS

Order test piles 10 feet longer in length than production piles. Drive the additional test pile length only when based upon the recommendation of the Contractor's Geotechnical Consultant and approved by the Owner's Representative. The Contractor's Geotechnical Consultant will use test pile data to determine "calculated" pile tip elevation and necessary driving resistance. This information will be given to the Contractor and the Engineer no later than 7 days from receipt of complete test data. Use this list as the basis for ordering the piles. Do not order piles until list is provided by the Contractor's Geotechnical Consultant to the Owner's Representative. Provide test piles 5 feet longer than the bid length.

2.2 MATERIALS

2.2.1 Steel Pipe Piles

ASTM A252, Grade 3. Provide test piles identical to those used elsewhere in the project. Provide full length steel pipe piles of the shape, size and sections shown in the drawings. Pipe piles must be either seamless pipe or full penetration welded with straight or spiral seams. Pipe must be welded in a manner that welding will not crack or fail when the pile is subjected to its intended use, including during installation. The weld seam of each length of pipe must be tested for acceptance by ultrasonic testing in accordance with the provisions for Nondestructive Electric Test of Weld Seam of ASTM A53/A53M.

2.2.2 Pile Splices

Submit detail drawings of shop and field pile splices prior to fabrication. Provide ASTM A148/A148M Grade 90-60 proprietary pile splicer sleeves or provide ASTM A109/A109M or ASTM A36/A36M backing rings to prevent weld blow out during weld process. Submit procedure for insufficient pile length.

2.2.3 Pile Shoes

Submit details about pile shoes used, if any. ASTM A148/A148M Grade 90/60 for cast steel cutting shoe. Submit Certificates of compliance certifying that materials meet the requirements specified herein. Provide inside flange open end cutting shoe on all pipe piles. Perform all welding in accordance with the requirements for pile splices.

2.2.4 Pile Caps and Pile Inserts

Provide ASTM A572/A572M Grade 50 plates for pile caps and pile inserts. Pile caps must conform to details shown.

2.2.5 Fabrication

Fabrication must conform to the requirements shown and as specified herein and in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS. Submit steel plant certification.

2.2.5.1 Pile Splices

Perform welding in accordance with the requirements for shield metal arc welding of AWS D1.1/D1.1M. Submit welding procedure for shop splices and verification of welder certification and qualifications. Make no more than one field splice, unless directed by the Engineer of Record. All field splices must be approved by the Engineer of Record. Fabrication drawings must show all shop splices.

Only use welders qualified by tests prescribed by AWS D1.1/D1.1M.

Splice sections of pipe with an approved full penetration butt or single bevel-groove weld. Both pipe ends must be square cut and seated to bear. Use an approved jig or alignment device during welding to maintain the required straightness of pipe. Field splices must be minimized or eliminated if possible. No splices will be allowed in the top 25feet of pile to eliminate coating vulnerability. For splices made during pile installation, rigid frame pile leads may be used as a jig in a manner approved by the Engineer of Record.

See paragraph FIELD QUALITY CONTROL for requirements.

2.2.5.2 Pile Caps

Ground the top of piles sufficiently smooth to provide a good welding surface for structural-shape pile caps.

2.2.5.3 Fusion-Bonded Epoxy Coating

Pipe piles must have fusion-bonded epoxy coating applied from the cutoff elevation to 14-feet below mean low water. Coating of steel surfaces with an electrostatically applied fusion-bonded epoxy must be in accordance with ASTM A972/A972M. Submit supporting product data and details for fusion-bonded epoxy coating.

2.3 PILE DRIVING EQUIPMENT

Select the proposed pile driving equipment, including hammers and other required items, and submit complete descriptions of the proposed equipment in accordance with paragraph SUBMITTALS. Final approval of the proposed equipment is subject to the satisfactory completion and approval of pile tests. Submit pile test plan at least 30 calendar days prior to installing any test piles. Approval of the plan will not relieve the Contractor of the responsibility for structural and operational adequacies of the testing system. Changes in the selected pile driving equipment will not be allowed after the equipment has been approved except as directed. No additional contract time will be allowed for Contractor proposed changes in the equipment.

2.3.1 Pile Driving Hammers

Pile driving hammers to be selected by Contractor and approved by Owner’s Representative. Provide impact or vibratory type pile driving hammers as needed.

2.3.1.1 Impact Hammers

Provide air, hydraulic or diesel-powered impact pile hammers of the single-acting, double-acting, or differential-acting type. The size or capacity of hammers must be as recommended by the hammer manufacturer for the total pile weight and the character of the soil formation to be penetrated. Ensure the hammer is capable of driving to a tensile capacity of 220 kips uplift load. Hammers must be capable of hard driving in excess of 20 blows per one inch. Provide boiler, compressor, or engine capacity sufficient to operate hammers continuously at the full rated speed. Hammers must have a gage to monitor hammer bounce chamber pressure for diesel hammers or pressure at the hammer for air hammers. This gage must be operational during the driving of piles and be mounted in an accessible location for monitoring by the Contractor and the Owner's Representative. Provide two spare operational bounce chamber read out units on site. Provide bounce chamber pressure gage correction tables and charts for the type and length of hose to be used with the pressure gage to the Owner's Representative. Hydraulic hammers must be equipped with a system for measurement of ram energy. The system must be in good working order and the results must be easily and immediately available to the Engineer. Install an energy monitor on the hydraulic hammers and record readings every 10 inches of pile installation. Use wave equation analysis to verify that the hammer will develop stresses within acceptable limits in the piles. Position a pile cap or drive cap between the pile and hammer. Place hammer cushion or cap block between ram and the pile cap or drive cap. Hammer cushion or cap block must have consistent elastic properties, minimize energy absorption, and transmit hammer energy uniformly and consistently during the entire driving period. In accordance with paragraph SUBMITTALS, submit the following information for each impact hammer proposed:

a. Make and model.

b. Ram weight (pounds).

c. Anvil weight (pounds).

d. Rated stroke inches.

e. Rated energy range foot-pounds.

f. Rated speed (blows per minute).

g. Air pressure, hammer, and boiler [and] [or] compressor psi.

h. Rated bounce chamber pressure curves or charts, including pressure correction chart for type and length of hose used with pounds per square inch.

i. Pile driving cap, make, and weight (pounds).

j. Cushion block dimensions and material type.

k. Power pack description.

2.3.1.2 Vibratory Hammers

The use of vibratory hammers is dependent upon satisfactory driving and load testing of piles. Final approval of the proposed hammer and other driving equipment is subject to the satisfactory completion and approval of the pile tests. The size or capacity of hammers must be as recommended by the hammer manufacturer for the total pile weight and the character of the soil formation to be penetrated. The hammer must provide for maintaining a rigid connection between the hammer and the pile. In accordance with paragraph SUBMITTALS, submit the following information for each vibratory hammer proposed:

a. Make and model.

b. Eccentric moment (inch-pounds).

c. Dynamic force (tons).

d. Steady state frequency or frequency range (cycles per minute).

e. Vibrating weight (pounds).

f. Amplitude (inches).

g. Maximum pull capacity (tons).

h. Non-vibrating mass weight (pounds).

i. Power pack description.

2.3.2 Pile Driving Leads

Support and guide hammers with fixed extended leads or fixed underhung leads. For driving battered piles, support and guide impact hammers with three-axis, fixed-extended leads capable of 1 H and 2-1/2 V before and after batter and 1 H on 6 V side batter, with 30-degree rotation each side of an axis running along the center line of rotation of the crane through the center line of the leads. Provide two intermediate supports for the pile in the leads to reduce the unbraced length of the pile during driving and pulling.

2.3.3 Pile Extractors

Pile extractors may be vibratory or impact pile driving hammers. Impact hammers are required for pulling piles not extractable with vibratory hammers.

PART 3 EXECUTION

3.1 PRELIMINARY WORK

3.1.1 Wave Equation Analysis of Pile Drivability

a. Prior to driving any pile, submit a pile Wave Equation Analysis, performed by Contractor's Geotechnical Consultant, for each size pile and distinct subsurface profile condition. These analyses must take into account the proposed hammer assembly, pile cap block and cushion characteristics, the pile properties and estimated lengths and the soil properties anticipated to be encountered throughout the installed pile length based on static capacity analysis with consideration of driving gain/loss factors. Only one specific model of pile hammer may be used for each pile type and capacity.

b. Demonstrate using the Wave Equation Analysis that the piles will not be damaged during driving, indicate that the driving stresses will be maintained within the limits below and indicate the blow count necessary to achieve the required tip elevation.

Allowable Driving Stresses

Steel Piles

Compression - 0.9 fy
Tension - 0.9 fy

Where fy is yield strength of steel

c. Perform a refined Wave Equation Analysis upon completion of the dynamic and static testing programs outlined in this specification section, taking into consideration the evaluated capacities, required tip elevations, gain/loss factors and recommended production pile lengths. Develop production pile driving criteria based on the results of the refined Wave Equation Evaluations.

d. All pile driving equipment provided by the Contractor will be subject to the approval of the Contractor's Geotechnical Consultant. Complete the attached pile and driving equipment data form, including hammer information, in full as part of the submittal of the results of the Wave Equation Analyses.

e. Pay for the cost of performing the Wave Equation Analyses and include in the base bid.

3.2 INSTALLATION

Inspect piles when delivered and when in the leads immediately before driving. Cut piles at cutoff grade by an approved method. Where cutoff is below existing ground or mudline elevation, complete excavation, sheeting, and dewatering before driving pile to driving criteria.

3.2.1 Probe Pile Program

Install a minimum of three probe piles at production pile locations identified by the Contractor and approved by the County and the Engineer of Record. One of these locations shall be in each of the following three areas: 1) along the North Embankment Wall; 2) along the front edge of the Approach Slab; and, 3) along the South Embankment Wall. Perform pile load testing on each of these piles as specified in Section 3.3.1 Test Piles. Use the probe pile program to evaluate installation methods, pile capacity, anticipated driving resistance, potential refusal, vibrations from pile driving, predrilling

requirements, and potential grouting requirements. Adjust installation procedures and hammer selection to meet requirements of the project documents.

3.2.2 Lengths of Production Piles

The estimated quantities of piles are given for bidding purposes only. Drive piles to or below indicated tip elevation.

3.2.3 Pile Driving Records

Keep a complete and accurate record of each pile driven. Indicate the pile location, deviations from pile location, cross section shape and dimensions, original length, ground elevation, tip elevation, cut-off elevations, number of blows required for each foot of penetration and number of blows for the last 6 inches penetration or fraction thereof as required for the "calculated" driving resistance. Include in the record the beginning and ending times of each operation during driving of pile, type and size of hammer used rate of operation, stroke or equivalent stroke for diesel hammer, type of driving helmet, and type and dimension of hammer cushion (capblock) and pile cushion used. Record retap data and unusual occurrences during pile driving such as redriving, heaving, weaving, splicing, obstructions, jetting, and any driving interruptions. Install an energy monitor on the hammers and record readings during pile installation. A preprinted pile driving log for recording pile driving data and pile driving equipment data form can be downloaded at: https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables.

3.2.4 Pile Placement and Tolerances in Driving

Develop and submit a pile placement plan which shows the installation sequence and the methods proposed for controlling the location and alignment of piles. Submit pile placement plans at least 30 calendar days prior to delivery of piles to the job site. Complete all foundation preparation in the area prior to the placement of piles for driving. Accurately place piles in the correct location and alignments, both laterally and longitudinally and to the vertical. Establish a permanent base line to provide for inspection of pile placement by the Owner's Representative during pile driving operations prior to driving production piles and maintain during the installation of the production piles.

Pilings must be installed with tolerances that will permit the installation of the structural steel bracing and sheet piling. Manipulation of previously driven piles to force them into position will not be permitted. Check all piles for heave prior to cut-off and following adjacent pile driving. Re-drive all heaved piles to the required tip elevation.

3.2.4.1 Survey Data

After the driving of each pile group is complete and before superimposed concrete is placed, provide the Owner's Representative with an as-driven survey showing actual location and top elevation of each pile. Submit the as-driven survey showing actual location and top elevation of each production pile and test piles that will serve as a production piles within 7 calendar days of completing the pile installation. Do not proceed with placing concrete until the Owner's Representative has reviewed the survey and verified that the proper cutoff wall tip elevation for the pile group has been provided. Present a survey in such form that it gives deviation from plan location in two perpendicular

directions and elevations of each pile to nearest half inch. Survey must be prepared and certified by a land surveyor licensed in The State of Florida.

3.2.5 Pile Penetration Criteria

The controlling driving resistance for production piles will be determined by the Contractor's Geotechnical Consultant with the governing criteria established by the required tip elevation provided in the project documents. The required initial driving criteria and restrike will be established subsequent to the analysis of pile tests as specified in paragraph PILE TESTS.

3.2.6 Pile Length Markings

Mark each pile prior to driving with horizontal lines at one-foot intervals. Mark the interval number on pile every 5 feet from pile tip.

3.2.7 Pile Driving

Notify Owner’s Representative 10 days prior to driving of test piles and load test. Submit records for test piles and data for load tests. The Contractor's Geotechnical Consultant will determine the terminal driving criteria based on results of dynamic pile driving tests at the end of drive or restrike, static load tests wave equation analysis. Stop foundation excavation at one foot above foundation grade before piles are driven. Do not drive piles within 100 feet of concrete less than 7 days old. Complete excavation to lines and grades shown when pile driving is completed. Drive piles to the indicated tip elevation. During initial driving and until pile tip has penetrated beyond layers of very soft soil or below bottom of predrilled holes, use a reduced driving energy of the hammer as required to prevent pile damage. If a pile fails to reach "calculated" indicated tip elevation, or if a pile reaches "calculated" tip elevation without reaching required driving resistance corresponding to the required uplift capacity, notify Owner’s Representative and perform corrective measures as directed. Provide hearing protection when noise levels exceed 140 dB. Do not handle or move piles or pile sections in any manner that would result in cracking or permanent damage to the existing structures. Piles may be driven without pile guides or leads providing a hammer guide frame is used to keep the pile and hammer in alignment.

The use of a vibratory hammer will be permitted above the final 10-feet of driving below which an impact hammer will be required.

3.2.7 Protection of Piles

Take care to avoid damage to piles during handling, placing pile in leads, and during pile driving operations. Support piles laterally during driving but allow rotation in leads. Where pile or projecting reinforcement orientation is essential, take precautionary measures to maintain the orientation during driving. Take special care in supporting battered piles to prevent excessive bending stresses in pile. Maintain axial alignment of pile hammer with that of the pile. If the Contractor elects to use a pile head with projecting strands or mild steel reinforcement, prevent direct impact forces from being transmitted through the reinforcement, by using a special driving head.

3.2.8 Pulling and Redriving

Withdraw piles damaged or impaired for use during handling or driving, mislocated, or driven out of alignment beyond the maximum tolerance as directed by the Engineer. Replace with new piles or cut-off and abandon damaged or impaired piles and drive new piles as directed. Remove excess cut-off from piles and unacceptable piles from the work site. Perform all work in connection with withdrawing and removing rejected piles from the site at no additional cost to the Owner.

If pipe piles meet refusal prior to achieving the design tip elevations, use alternate methods to advance the pile such as drilling through the pile as necessary to achieve both the required load capacity for cofferdam stability and the required seepage cutoff depth. Exhaust all reasonable means at no additional cost to the Owner to advance the pile prior to making a request to the Engineer for removal. If the pile achieves the required load capacity without reaching the required tip elevation, jet grouting or similar method will be required to create a low permeability zone below the bottom of the pile to the required elevation and at no additional cost to the County.

3.2.8.1 Obstructions

If a pile encounters an underground obstruction of such size as to prevent driving the pile to the required driving criteria, drill through the center of the pile to remove the obstruction at no additional cost to the Owner. If such action does not permit pile advancement, recommend alternative measures for approval by Owner's Representative at no additional cost to the Owner.

3.2.8.2 Splicing Piles

Make splices as indicated on the approved shop drawings. Splices must be capable of developing the full strength of the member in compression, tension, shear, and bending. Submit detail drawings of splices and design calculations demonstrating the strength of the splice for approval.

3.2.9 Jetting of Piles

Water jets will not be permitted.

3.2.10 Predrilling of Piles

Predrilling to remove soil or other material representing the bulk of the volume of the pile to be driven will be permitted at no additional cost to the County. The diameter of the hole must not exceed two-thirds the width of the pile. Discontinue drilling when the pile tip is approximately 10 feet above the required pile tip elevation. Vibratory driving methods not allowed in the final 10 feet of penetration or more to meet the required driving criteria.

3.2.10.1 Heaved Piles

When driving piles in clusters or under conditions of relatively close spacing, perform observations to detect heave of adjacent piles. Backdrive heaved piles to the required tip elevation as directed by the Contractor's Geotechnical Consultant, after reviewing the heave data, without additional cost to the Owner.

3.2.10.2 Pulled Piles

Pull and replace piles damaged or impaired for use during driving with new piles or cut off and abandon and drive new piles as directed without additional cost to the Owner. The Owner's Representative may require that any pile be pulled for inspection. Redrive piles pulled as directed and found to be in suitable condition at another location as directed. Replace piles pulled as directed and found to be damaged with new piles at the Contractor's expense.

3.2.10.3 Long Piles

Provide pile driving rig with rigid supports so that leads remain accurately aligned. Where a high degree of accuracy is required, erect templates or guide frames at or close to the ground or water surface.

3.2.10.4 Welding

AWS D1.1/D1.1M. Welding of splices must conform to the requirements of Section 05 50 14 STRUCTURAL METAL FABRICATIONS. Shop and field welding, qualification of welding procedures, welders, and welding operators must be in accordance with AWS D1.1/D1.1M.

3.2.11 Protection of Existing Structures

Mitigate impact on existing facilities due to pile driving activities in accordance with the project specific document.

3.2.12 Concrete Infill

Mix and place concrete infill in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Concrete shall be placed to the elevations as shown on the Drawings.

3.3 FIELD QUALITY CONTROL

3.3.1 Test Piles

Ten test piles will be ~~load~~ load-tested as specified below to confirm that the required tip elevation has been reached and the required uplift capacity has been achieved.

3.3.1.1 Dynamic Pile Analysis

Dynamic testing provides supplemental information for evaluating pile integrity, hammer and drive system performance, assess pile installation driving stresses, and pile capacities. Perform dynamic testing on all eight (8) of the approach channel piles and on two additional piles to be determined by the engineer. Restrike all eight (8) piles a minimum of 2 days after initial driving. Restrike must be performed with Dynamic Pile Testing. The minimum required tension capacity of these piles is 220 kips. Provide equipment to obtain dynamic measurements, record, reduce and display its data that meet the requirements of ASTM D4945 and Division 2 of the FDOT Specifications, Section 455 – Structures and Foundations. The equipment must have been calibrated within 6 months prior to the start of the testing operations and thereafter throughout the contract duration. Employ an independent inspection firm, hereinafter referred to as the "Contractor's Geotechnical Consultant", experienced in the pile driving process, monitoring of test pile installation, and in the use of the Pile

Driving Analyzer (PDA) and its related equipment. Submit a performance report summarizing dynamic test results for piles within 7 calendar days of completing field work. For all other piles, submit a performance report within one day of testing. Submit a typed pile driving report summarizing the results of piles on a monthly basis. Perform dynamic pile analysis as follows:

3.3.1.2 Pile Analyzing

Ten working days prior to driving the piles, submit the pile and complete driving equipment data to the Owner's Representative. The Contractor's Geotechnical Consultant must use the submitted information to perform wave equation analyses and must prepare a summary report of the wave equation results. The wave equation analysis using GRLWEAP software by Pile Dynamics, Inc. or equivalent must be used to assess the ability of the proposed driving system to install the pile to the required uplift capacity and desired tip elevation within the allowable driving stresses. Approval of the proposed driving system by the Owner's Representative must be based upon the wave equation analyses indicating that the proposed driving system can develop a pile capacity of 220 kips of uplift at a driving resistance not greater than 20 blows per inch within allowable driving stress limits. The hammer must also be sized or adjustable such that the penetration per blow at the required ultimate capacity does not exceed 0.5 inches.

3.3.1.3 Pile Drivability

Perform each dynamic pile analysis in two steps. The first step is to check the hammer, pile and soil performance, and to determine the suitability of the proposed hammer for the size, length and type of pile being installed for the soil types encountered as the piles are driven. This initial monitoring must determine whether pre-augering is appropriate, efficiency of the hammer relative to specified efficiency, effectiveness of cushion, level of compressive and tensile stress in pile and extent/location of any pile damage caused by the initial driving. With each blow of the pile, record the information listed below electronically and analyze the information using the Pile Driving Analyzer:

a. Blow number

b. Blow rate per minute and stroke.

c. Input and reflected values of force and velocity.

d. Value of upward and downward traveling force wave with time.

e. Maximum and final transferred energy to pile, hammer system efficiency.

f. Maximum compressive stress, velocity, acceleration and displacement.

g. Maximum tensile stress in pile.

h. Pile structural integrity, damage detection, extent and location.

i. Bearing capacity of pile by Case method.

j. Tip elevation

If the pile, hammer and soil performance evaluation recommend changes to the hammer stroke, pile cushioning, augering or any other aspect for the pile driving operation, incorporate these changes into production pile driving in an effort to control excessive stresses and pile damage. Replace test piles damaged or broken during installation, incorporating driving modifications as determined by the Contractor's Geotechnical Consultant and reviewed and approved by the Owner's Representative. Repeat this procedure until allowable tensile and compressive stresses are achieved in the pile and pile damage is minimized. Subject selected initial driving records to rigorous computer analysis by the Case Pile Wave Analysis Program (CAPWAP) for determination of resistance distribution, soil resistance and properties, and estimation of anticipated gain/loss factors.

3.3.1.4 CAPWAP

Signal matching analysis by CAPWAP software of the dynamic pile testing data must be performed on data obtained from the end of initial driving and the beginning of restrike of all control piles. CAPWAP analyses must be performed by an engineer who has achieved Advanced Level or better on the PDI / PDCA Dynamic Measurement and Analysis Proficiency Test for Providers of PDA Testing Services.

Upon completion of test pile driving, allow the piles to set-up for at least 48 hours. After evaluation of pile, hammer and soil performance by the Contractor's Geotechnical Consultant, the second step of the dynamic pile analysis may proceed. This portion of the evaluation requires striking the set-up piles a minimum of 20-50 times, or as directed by the Contractor's Geotechnical Consultant using the same hammer which was used for the pile driving and which will be used for production pile driving. "Warm up" the hammer and make it optimally ready prior to restriking, in order to avoid capacity losses during evaluation of restrike data. Apply maximum hammer energy during restrike in order to fully mobilize the soil resistance. However, exercise care so as to not overstress the pile. In addition to those items listed above, selected restrike driving records as directed by the Contractor's Geotechnical Consultant are to be subjected to rigorous computer analysis by the Case Pile Wave Analysis Program (CAPWAP) for determination of resistance distribution, soil resistance and properties, and plot of applied load vs. average pile displacement based on the calculated soil properties.

3.3.1.5 Dynamic Load Test Reporting

a. Upon satisfactory completion of each dynamic load test, submit a minimum of three copies of a Pile Performance Report for the Contractor by the Contractor's Geotechnical Consultant. The submittal must be prepared and sealed by a Professional Engineer registered in Florida.

b. The report for the Dynamic Pile Analysis must contain the following information:

(1) Capacity of pile from Case Pile Wave Analysis Program (CAPWAP). Information resulting from analysis of a selected restrike blow.

(2) Maximum and final transferred energy, hammer system efficiency during pile installation.

(3) Maximum compressive stress, velocity, acceleration and displacement.

(4) Maximum tensile stress in pile.

(5) Pile structural integrity, damage detection, extent and location.

(6) Blows per minute and blow number.

(7) Input and reflection values of force and velocity, upward and downward traveling force wave with time.

(8) Pile skin friction and toe resistance distribution.

(9) Maximum energy transferred to pile.

(10) Tip elevation

Use either a Model 8G or PAX Pile Driving Analyzer as manufactured by Pile Dynamics, Inc., of Cleveland Ohio or approved equivalent, for dynamic testing of the pile hammer and for dynamic load testing of the test pile. All equipment necessary for the dynamic monitoring such as sensors, cables or wireless transmitters, must be furnished by the Contractor's Geotechnical Consultant. The equipment must conform to the requirements of ASTM D4945.

No additional payment will be made for services of the Contractor's Geotechnical Consultant. The Contractor's Geotechnical Consultant must be available throughout the pile driving operation to consult with the Engineer of Record when required by the Engineer of Record. The cost of changes in the Contractor's procedure, as required by evaluation of the results of the Pile Driving Analysis, will be at the Contractor's expense.

3.3.2 Pile Records

Keep a complete and accurate record of each pile driven. Indicate the pile location, deviations from pile location, cross section shape and dimensions, original length, ground elevation, tip elevation, cut-off elevations, number of blows required for each foot of penetration and number of blows for the last 6 inches penetration or fraction thereof as required for the "calculated" driving resistance. Include in the record the beginning and ending times of each operation during driving of pile, type and size of hammer used rate of operation, stroke or equivalent stroke for diesel hammer, type of driving helmet, and type and dimension of hammer cushion (capblock) and pile cushion used. Record retap data and unusual occurrences during pile driving such as redriving, heaving, weaving, splicing, obstructions, and any driving interruptions. Submit to the Engineer of Record complete and accurate test and production pile driving records within 15 calendar days after completion of driving. Make pile driving records available to the Engineer of Record at the job site, within 24 hours after each day of pile driving. A preprinted pile driving log for recording pile driving data and pile driving equipment data form can be downloaded at: https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables.

3.3.3 Testing Agency Qualifications

Engage an independent testing agency to observe the production piles installation. The testing agency must be qualified according to ASTM E329 for testing indicated. Submit testing agency qualifications to the Owner's Representative for approval.

3.3.4 Welding Inspection

Employ a testing agency to perform the welding inspections as specified in the statement of special inspection.

3.3.5 Weld Testing

In addition to visual inspection, welds must be tested and inspected according to AWS D1.1/D1.1M and inspection procedures listed below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate do not comply with the Contract Documents. Test 10 percent of pile splices, the steel pile cap splice connections and the steel pile insert connection.

a. Liquid Penetrant Inspection: ASTM E165/E165M.

b. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.

c. Ultrasonic Inspection: ASTM E164.

3.4 TOUCHUP PAINTING

Clean field welds, splices, and abraded painted areas and field-apply paint according to SSPC PA 1. Use same paint and apply same number of coats as specified. Apply touchup paint before driving piles to surfaces that are immersed or inaccessible after driving.

3.5 VIBRATION CONTROL

Perform vibration monitoring at strategic locations determined by the Owner's Representative and number of locations as follows:

Approach Walls:	3
Coarse Screen Chamber:	1
Ogee:	3
Training Walls:	3
Fine Screen Chamber:	1

Vibration Control locations will be decided by the Owner's Representative during the pile driving operations. Perform vibration monitoring seismographs, accelerometer and/or geophones within a distance of 200 feet from the pile driving activity. Engage the services of a qualified, independent vibration consultant, acceptable to the Owner, to conduct the vibration monitoring. The vibration consultant must have minimum of five years of experience in vibration monitoring. A minimum of 14 days before the installation of vibration monitors, submit to the Owner the name of the vibration consultant and a list of at least three previously completed projects of similar scope and purpose.

Prior to the pile driving activities, obtain baseline readings of ambient vibrations on each of the components of the structure being monitored. The vibration during the pile driving activities must be limited to a peak particle velocity of not more than 2.0 inches per second. During pile driving activities, monitor the vibrations to ensure the limits are not exceeded. If the limits are exceeded, cease the pile driving activity causing the vibration until the Vibration consultant and the Owner's Representative are on site to observe the structures nearest to the vibration monitor which has exceeded the limits. Provide alternate drilling options for the Owner's Representative to review and accept.

The Contractor is responsible for all damages resulting from the pile driving operations and must take whatever measures necessary to maintain peak particle velocity within the specified limit. After completion of the project, remove the vibration monitors off the site and off Owner property and restore the monitoring locations back to their original condition.

3.6 CONSTRUCTION INSTRUMENTATION AND MONITORING PROGRAM

Prepare a geotechnical instrumentation program to monitor in real time the settlement and lateral movement of temporary and permanent structures, utilities, embankments and excavations during pile driving. The design and distribution of instrumentation must demonstrate an understanding of the need, purpose and application of each proposed type. Perform vibration monitoring in accordance with VIBRATION CONTROL sections.

Crest of the Dam: 4 (Settlement), check select control points on the structure each month for displacement (upstream and downstream)
Approach Walls: 4
Ogee: 3
Training Walls: 4

Engineer will select the locations to be monitored and reserves the right to adjust locations during driving operations at no additional cost to the Contractor.

Monitoring must extend before, during and for a period after completion of construction activities related to pile driving when long-term performance issues are a concern. The monitoring plan must be designed to protect adjacent structures and utilities against damage due to the pile driving activities. Establish limiting values of vertical and horizontal movement for each structure and utility within the zone of influence, subject to review by the Owner.

Embankment: 1-inch, maximum (vertical and horizontal)
Concrete Structures: 1/8-inch (vertical and horizontal)
Bridge Deck: 1/8-inch (vertical and horizontal)

Prepare a report detailing the proposed program of instrumentation and monitoring, establishing threshold values of monitored parameters, and describing the response plans that will be implemented when threshold parameters are exceeded. The report must include details about instrumentation consultant's experience, appropriate types, quantities, locations and monitoring frequencies of the instruments.

Upon acceptance of the instrumentation and monitoring program, provide, install and monitor the instrumentation and interpret the data. Submit instrumentation and monitoring program reports not less than every driving operation and no less than 1 day after the monitoring program has begun. Take corrective actions, as necessary, based on the field instrumentation data and as defined in the instrumentation and monitoring program.

-- End of Section --