

Preparing Activity: USACE

New

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2023

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USACE / NAVFAC / AFCEC / NASA

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Preparing Activity: USACE

New

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2023

SECTION 31 41 16.16

SYNTHETIC SHEET PILING
05/23

NOTE: This guide specification covers the requirements for synthetic sheet piling. This section was originally developed for USACE Civil Works projects.

Adhere to [UFC 1-300-02](#) Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a [Criteria Change Request \(CCR\)](#).

PART 1 GENERAL

NOTE: Permanent earth retaining structures made with PVC or FRP sheet piling such as bulkheads, quay walls, flood walls, cutoff walls, and retaining walls are covered by this section. Temporary structures such as shoring and sheeting are the responsibility of the Contractor and unless required by conditions of the project, are not to be covered by this section. The extent and location of the work to be accomplished should be indicated on the project drawings.

The following information must also be shown on the project drawings:

1. Location of piles.
2. Soil data, where required.
3. Pile shape.
4. Allowable moment.
5. Length or tip and cut-off elevations.
6. Waler types, sizes, and locations, where required.
7. Tie-rod or soil anchor size, spacing and material, where required.
8. Anchorage type, size, and location, where required.

NOTE: This specification is intended for the use of NEW synthetic sheet piling. Synthetic structural design is often deflection-controlled instead of strength-controlled. Be sure to check or require deflection limits for serviceability. An example of a maximum deflection limit is less than 2 percent of the span; such as the distance from the lowest wale support to the ground line. Typically, it is more economical to design PVC sheet pile walls as an anchored wall system. For background information on synthetic piling and considerations, see: USACE EM 1110-2-2502, USACE ERDC/CRREL LR-03-19 A Study of the Long-term Applications of Vinyl Sheet Piles, USACE Interim Report - General Design Guide: PVC Sheet Pile, ASCE Pre-Standard for Load & Resistance Factor Design (LRFD) of Pultruded Fiber Reinforced Polymer (FRP) Structures.

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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.

ASTM INTERNATIONAL (ASTM)

ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D2343	(2017) Standard Test Method for Tensile Properties of Glass Fiber Strands, Yarns, and Rovings Used in Reinforced Plastics
ASTM D3917	(2015a) Standard Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes
ASTM D4216	(2017) Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) and Related PVC and Chlorinated Poly (Vinyl Chloride) (CPVC) Building Products Compounds
ASTM D4385	(2010) Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products
ASTM D5379/D5379M	(2019; E 2021) Standard Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method
ASTM D6641/D6641M	(2016; E 2021) Standard Test Method for Compressive Properties of Polymer Matrix Composite Materials Using a Combined Loading Compression (CLC) Test Fixture
ASTM D7290	(2006; R 2022) Standard Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications
ASTM D8427	(2021) Standard Specification for Rigid Poly Vinyl Chloride (PVC) Exterior Profiles Used for Sheet Piling
ASTM E329	(2021) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
ASTM E548	(1994; E 1995) Standard Guide for General Criteria Used for Evaluating Laboratory Competence

1.2 UNIT PRICES

NOTE: If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is included in the project

specifications, this paragraph title (UNIT PRICES)
should be deleted from this section and the
remaining appropriately edited subparagraphs below
should be inserted into Section 01 20 00.

1.2.1 [PVC Sheet Piling, Type [____]] [FRP Sheet Piling, Type [____]]

1.2.1.1 Payment

Payment for sheet piling quantities will be made at the applicable contract price per linear foot for furnished and installed sheet piling. Payment will cover all cost of furnishing, handling, storing, and installing piling including placing, driving, cutting holes and other materials and work incident thereto.

1.2.1.2 Measurement

The length of sheet piling installed [and removed] will be measured to the nearest tenth of a linear foot. For installed pilings directed to be cut off before reaching the penetration depth indicated, the portion cut off will be measured for payment as the difference between the total length of piling indicated for that location and the length of piling installed below the point of cut-off.

1.2.1.3 Unit of Measure

Unit of measure: linear meterfoot.

1.2.2 [PVC Sheet Piling - Government Furnished] [FRP Sheet Piling - Government Furnished]

1.2.2.1 Payment

Payment for sheet piling quantities will be made at the applicable contract price per linear foot for furnished and installed sheet piling. Payment will cover all cost of furnishing, handling, storing, and installing piling including placing, driving, cutting holes and other materials and work incident thereto [except the cost of furnishing piling will not be included in the contract price for Government furnished piling].

1.2.2.2 Measurement

The length of sheet piling installed [and removed] will be measured to the nearest tenth of a linear foot. For installed pilings directed to be cut off before reaching the penetration depth indicated, the portion cut off will be measured for payment as the difference between the total length of piling indicated for that location and the length of piling installed below the point of cut-off.

1.2.2.3 Unit of Measure

Unit of measure: linear meterfoot.

1.2.3 Cut-Offs

1.2.3.1 Payment

When pilings which have not been driven to penetration depths indicated are directed to be cut off, except for cut-offs due to excessive battering, a lump sum payment will be made for cutting off each piling.

1.2.3.2 Measurement

An additional sum will be paid for each linear meter foot of the portion cut off and measured for payment. For installed pilings directed to be cut off before reaching the penetration depth indicated, the portion cut off will be measured for payment as the difference between the total length of piling indicated for that location and the length of piling installed below the point of cut-off at the rate of 50 percent of the applicable contract unit price.[No payment will be made for cut-off portions of Government furnished pilings.]

1.2.3.3 Unit of Measure

Unit of measure: linear meterfoot.

1.2.4 Splices

Splicing of [PVC] [FRP] sheet piling is prohibited.

1.2.5 Pulled Pilings

1.2.5.1 Payment

The Contractor furnished pilings which have been installed and are pulled at the direction of the Contracting Officer and found to be in good condition will be paid for at the applicable contract unit price for furnishing and installing the pilings in their initial position plus an equal amount for the cost of pulling.

1.2.5.2 Measurement

When such pulled pilings are redriven, an additional amount equal to 50 percent of the applicable contract unit price for furnishing and driving the pilings will be paid for redriving the pilings. This additional price constitutes payment for redriving only. The cost of furnishing, initial driving, and pulling the pilings is to be paid for as specified.

- a. Government furnished pilings which are pulled at the direction of the Contracting Officer and found to be in good condition will be paid for at the applicable contract unit price for installing the pilings in their initial position plus an equal amount for the cost of pulling. Such piling when redriven will be paid for at the applicable contract unit cost for installing the pilings.
- b. When pilings are pulled and found to be damaged no payment will be made for the initial furnishing and driving or for the pulling of such pilings. Pilings replacing damaged pilings will be paid for at the applicable contract unit prices.

1.2.5.3 Unit of Measure

Unit of measure: each.

1.2.6 Removal of Sheet Pilings

1.2.6.1 Payment

Payment will be made for costs associated with removal of sheet pilings which have been installed and are removed at the direction of the Contracting Officer. Payment will cover the cost of pulling, cleaning the interlock, sorting, inventorying, and storing. No payment will be made if the pulled pilings are found to be defective or damaged due to Contractor negligence.

1.2.6.2 Measurement

Removal of sheet piling will be made at the applicable contract price per linear meter foot.

1.2.6.3 Unit of Measure

Unit of measure: linear meterfoot.

1.3 NAVY REQUIREMENTS

NOTE: Select the applicable paragraph(s) from the following.

1.3.1 Basis of Bids

NOTE: Use this option for fixed-price contracts.

Base bids on pile sections and lengths as indicated. Should the total number of piles or the number of each length vary from that specified as the basis for bidding, an adjustment in the contract price and time for completion will be made. No additional payment will be made for withdrawn, damaged, rejected, or misplaced piles; for any portion of a pile remaining above the cut-off elevation; for backdriving; for cutting off piles, or for any cut off length of piles.

1.3.2 Measurement and Payment

1.3.2.1 NAVFAC PAC Projects

For unit price bid, see SF 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items."

1.3.2.2 NAVFAC LANT Projects

Payment will be at the contract unit price per length, multiplied by the total length of acceptable piles actually installed. Base bids on the number of piles with pile length from tip to cutoff, as indicated, and on the total length of piling from tip to cutoff as specified in the document titled "Instructions to Bidders." Include in bid a unit price per unit

length piling based on the quantity stated in the document titled "Instructions to Bidders." If the Contracting Officer requires an increase or a decrease in length of piles furnished and installed, the contract price will be adjusted in accordance with the Contract Clauses of the Contract. The unit price bid will be used for upward or downward adjustment of the quantity subject to provisions of FAR 52.211-18, VARIATION IN ESTIMATED QUANTITIES.

1.4 ESTIMATED QUANTITIES

The estimated quantities of sheet piling listed in the unit price schedule of the contract, as to be furnished by the Contractor, are given for bidding purposes only. Sheet piling quantities for payment will consist of the linear meters feet of piling acceptably installed [and removed]. Installed quantities will consist of all piling including fabricated sections driven between the required top and bottom elevations of pilings plus any additions thereto resulting from changes in design or alignment as provided in paragraph DRIVING. [Removed quantities will consist of the lengths of piling pulled from below the ground level.]

1.5 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal

for the Government.] Submit the following in accordance with Section
01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Installation Procedures; G[, [____]]

Pile Driving Equipment; G[, [____]]

Pulling and Redriving Plan; G[, [____]]

[Instrumentation and Monitoring Program Report; G[, [____]]

] SD-02 Shop Drawings

Sheet Piling; G[, [____]]

As-Driven Survey; G[, [____]]

Pile Shoe; G[, [____]]

SD-03 Product Data

Driving; G[, [____]]

Pulling and Redriving; G[, [____]]

Delivery, Storage, and Handling; G[, [____]]

SD-06 Test Reports

Materials Tests

SD-07 Certificates

Pile Shoe; G[, [____]]

SD-11 Closeout Submittals

Pile Driving Record; G[, [____]]

1.6 DELIVERY, STORAGE, AND HANDLING

Materials delivered to the site must be new and undamaged and must be accompanied by certified test reports. Provide the manufacturer's name and mill identification mark on the sheet piling. Store and handle sheet piling in the manner recommended by the manufacturer to prevent permanent deflection, distortion, or damage to the interlocks; as a minimum, support on level blocks or racks spaced not more than 3 m 4 to 5 feet apart and not more than 0.60 m 2 feet from the ends. Storage of sheet piling should also facilitate required inspection activities and prevent damage to coatings and corrosion protection prior to installation. [Handle sheet piling over 80 feet long using a minimum of two pickup points.]

1.7 QUALITY ASSURANCE - MATERIAL CERTIFICATES

For each shipment, submit certificates provided by the sheet pile manufacturer prior to installing piling. Include in the identification data piling type, section depth, section width, sheet thickness, [cell

classification of PVC virgin resin used in co-extrusion or mono-extrusion process], and section modulus. The allowable bending stress must not exceed [3,200 psi for the PVC sheet.] [10,000 psi for the FRP sheet.]

[a. The PVC sheet piling certifications must consist of the following:

- (1) Certificate of analysis from an ISO certified compounder indicating that virgin material is of Class 1-4244-33 or superior in accordance with ASTM D4216.
- (2) Certificate showing compliance with the requirements of ASTM D8427.
- (3) Material certification indicating that the material being received by the Contractor is in accordance with the geometric and material requirements outlined in the specifications.
- (4) 50 year manufacturer's warranty. Reseller or outsourcer warranties are not sufficient.]

[b. The FRP sheet piling certifications must consist of the following:

- (1) Certification that the material was produced in accordance with the manufacturer's Quality Control Plan in an ISO 9001 compliant manufacturing facility.
- (2) Material certification indicating that all material properties have been characterized in accordance with ASTM D7290.
- (3) Material certification indicating that the material being received by the Contractor is in accordance with the geometric and material requirements outlined in the Contract Documents.
- (4) 20 year manufacturer's warranty.]

1.8 CONTRACTOR QUALIFICATIONS

The Contractor must have prior experience with driving [PVC] [FRP] sheeting and must provide a list of previous job(s) that demonstrate a satisfactory installation method. Coordinate with the sheet pile manufacturer and vibratory equipment supplier regarding their recommendations concerning the proper vibratory plates or hammer / equipment and tools.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit [to the Contracting Officer for approval] descriptions of pile driving equipment to be used in the work. Descriptive information includes manufacturer's name, model numbers, capacity, rated energy, hammer details, cushion material, helmet, templates, and jetting equipment.

2.2 [PVC] [FRP] SHEET PILING

NOTE: PVC/FRP sheeting is ideally suited for applications where corrosion is a design concern and when exposed wall heights are under 20-feet.

PVC/FRP should also be considered in cutoff applications and lower height and risk floodwall applications in accordance with EM 1110-2-2502, "Floodwalls and Other Hydraulic Retaining Walls."

Submit detailed shop drawings for sheet piling showing complete piling dimensions and details, sheet pile section properties, pieces used to turn all required corners as indicated, driving sequence, and location of installed piling.

Include in the drawings details of top protection, special reinforcing tips, tip protection, and dimensions of templates and other temporary guide structures for installing piling. Provide details and description of the method for handling piling to prevent permanent deflection, distortion or damage to piling interlocks, plus the type of transportation vehicle for bringing piles to the point of installation.

2.2.1 Interlocks

The interlocks of sheet piling must be free-sliding when sheets are plumb/level.

2.2.2 General Requirements

NOTE: Designers should contact suppliers to verify current availabilities and lead times. Based upon the design requirements for each piling section select the most suitable corresponding section from the available suppliers. Designers should place the pertinent section properties of this section on the drawings as minimum requirements.

[PVC sheet piling must be manufactured entirely from a rigid, high impact, UV-inhibited, weatherable vinyl compound. Provide PVC sheet piling in accordance with [ASTM D8427](#). All exposed surfaces of the sheet piling must be UV resistant and comprised of virgin material with a minimum [ASTM D4216](#) Cell Classification of 1-42443-33 to ensure reliable performance and color consistency. If mono-extrusion technology is used, the entire sheet pile must be comprised of virgin material with a minimum [ASTM D4216](#) Cell Classification of 1-42443-33.]

[FRP sheet piling must be vinyl ester resin thermoset pultruded shapes manufactured entirely from a rigid, high impact, UV-inhibited, weatherable fiberglass reinforced polymer. All exposed surfaces of the sheet piling must be UV resistant.]

- a. Determine lengthwise and transverse tensile modulus and strength in accordance with [ASTM D638](#).
- b. Determine by testing the lengthwise and transverse compression modulus and strength in accordance with [ASTM D6641/D6641M](#).
- c. Determine by testing the in-plane shear strength and modulus in accordance with [ASTM D5379/D5379M](#).

- d. Fiber reinforcements must meet the minimum tensile strength of 290 ksi in accordance with ASTM D2343.
- e. Calculate and submit the moment capacities in accordance with the ASCE Pre-Standard for Load and Resistance Factor Design (LRFD) of Pultruded Fiber Reinforced Polymer (FRP) Structures including the local compression flange buckling limit state. If using Allowable Stress Design, use safety factors of 2.5 for flexural stresses and 3.0 for shear and connection stresses.
- f. Meet the durability and environmental effects material requirements of the ASCE Pre-Standard for Load and Resistance Factor Design (LRFD) of Pultruded Fiber Reinforced Polymer (FRP) Structures.
- g. Visual requirements must be in accordance with ASTM D4385.
- h. Sheet pile section must contain UV light absorbers and stabilizers. Include a minimum 3 mil polyester or nylon veil.
- i. Dimensional requirements must be in accordance with ASTM D3917.

2.3 SHEET PROPERTIES

Sheet piling must be full-length sections of the dimensions indicated. Provide fabricated sections in accordance with the requirement and the piling manufacturer's recommendations for fabricated sections. Sheet piling must meet the following minimum properties:

Sheet Pile Location	Allowable Moment (ft-lbs./ft.)	Section Modulus (in ³ /ft.)	Moment of Inertia (in ⁴ /ft.)	Thickness (in.)	Depth (in.)	Coverage (in.)

[Color of the PVC sheet pile must be [____].] [Color of the FRP sheet pile must be [____].] Final color selection will be by the Engineer based on color samples submitted. Caps may be manufactured from [PVC] [FRP] [6063-T6 extruded aluminum] profiles suitable for covering the top surface of the sheet piles. Aluminum caps may be mill finish or anodized. Caps may also be reinforced concrete or wood. Wood caps must be coated with a UV resistant polymer. Sheet pile corners and caps may be PVC or 6061-T6 aluminum.

2.4 APPURTENANT METAL MATERIALS

Provide metal plates, shapes, bolts, nuts, rivets and other appurtenant fabrication and installation materials conforming to manufacturer's standards and to the requirements specified in Section 05 50 15 CIVIL WORKS FABRICATIONS.

2.5 PILE DRIVING EQUIPMENT

NOTE: Typical driving aids may include the use of a mandrel, an auger, or a pre-punch tool such as an I-beam or steel sheet pile.

Submit complete descriptions of sheet piling driving and installation equipment including hammers, [jetting equipment,] extractors, protection caps and other installation appurtenances including driving aids, prior to commencement of work. Provide pile driving equipment conforming to the following requirements.

2.5.1 Driving Hammers

Hammers must be single-acting, gravity drop, or vibratory type. The weight of the hammers must be determined jointly by the manufacturer and the Contractor for the piling products and subsurface materials to be encountered.

2.5.2 Jetting Equipment

Jetting [may be used at no additional cost to the Government] [is prohibited]. [Jetting equipment must have not less than two removable or fixed jets of the water or combination air-water type. Water jets must be designed so that the discharge volume and pressure are sufficient to freely erode the material under and adjacent to the piling.]

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

Requirements for material tests, workmanship, and other measures for quality assurance are as specified in this Section.

2.6.1 Materials Tests

Submit certifications from the suppliers of appurtenant metal materials showing that materials meet the specified requirements for each shipment. Certifications required for [PVC] [FRP] sheeting are referenced in paragraph QUALITY ASSURANCE - MATERIAL CERTIFICATES.

PART 3 EXECUTION

3.1 EARTHWORK

Perform in accordance with Section 31 00 00 EARTHWORK. Pre-excavation is [permitted] [prohibited] [permitted to a maximum depth [of [_____] meters feet below [_____] [as indicated]]. Backfill as indicated.

3.2 INSTALLATION

3.2.1 Placing

NOTE: When long piles are being driven, templates are of value. Long piles are very flexible and damage easily. Use templates to keep piles vertical.

Submit a written description of the site specific pile installation procedures for Government review and approval.

Excavation that is required within the area where sheet pilings are to be installed must be completed prior to placing sheet pilings. Pilings properly placed and driven must be interlocked throughout their length with adjacent pilings to form a continuous diaphragm throughout the length or run of piling wall.

- a. Pilings must be carefully located as [indicated] [or] [directed.] Pilings must be placed plumb with out-of-plumbness not exceeding [10] [22] mm per meter [1/8] [1/4] inch per foot of length and true to line. Place the pile so the face will not be more than 150 mm 6 inches from vertical alignment at any point. Top of pile at elevation of cut-off must be within 13 mm 1/2 inch horizontally and 50 mm 2 inches vertically of the location indicated. Manipulation of piles to force them into position is prohibited. Check all piles for heave. Re-drive all heaved piles to the required tip elevation.
- b. Provide temporary wales, templates, [master pilings] [current deflectors] or guide structures to ensure that the pilings are placed and driven to the correct alignment. Use a system of structural framing sufficiently rigid to resist lateral and driving forces and to adequately support the sheet piling until design tip elevation is achieved. Use a minimum of two templates when placing each piling [at third points] [not less than 6 m 20 feet apart]. Templates must not move when supporting sheet piling. Fit templates with wood blocking to bear against the web of each alternate sheet pile and hold the sheet pile at the design location alignment. Provide outer template straps or other restraints as necessary to prevent the sheets from warping or wandering from the alignment. Mark the template for the location of the leading edge of each alternate sheet pile. If in view, also mark the second level to assure that the piles are vertical and in position. If two guide marks cannot be seen, other means must be used to keep the sheet pile vertical along its leading edge.

3.2.2 Driving

NOTE: When hard driving or driving through rocky soil or debris is anticipated, require addition of tip protection or a steel mandrel to prevent damage to sheet piling.

Jetting should generally not be permitted for:

1. Piles dependent on side friction in fine-grained low permeability soils (high clay or silt content) where considerable time is required for the soil to reconsolidate around the piles.
2. Piles subject to uplift.
3. Piles adjacent to existing structures.
4. Piles in closely spaced clusters unless the load capacity is confirmed by tests and unless all jetting is done before final driving of any pile in the cluster.

Pre-augering or spudding should generally not be permitted for piles dependent on side friction in

fine-grained, low permeability soils (high clay or silt content) where considerable time is required for the soil to reconsolidate around the piles.

Submit records of the completed sheet piling driving operations, including a system of identification that shows the disposition of approved piling in the work, driving equipment performance data, piling penetration rate data, piling dimensions and top and bottom elevations of installed piling. [The format for driving records is as directed.] [Prior to driving pilings in water, paint a horizontal line on both sides of each piling at a fixed distance from the bottom so that it will be visible above the water line after installation. This line must indicate the profile of the bottom elevation of installed pilings and potential problem areas can be identified by abrupt changes in its elevation.] Drive pilings with the proper sized hammer and by approved methods to prevent damage to the pilings and to ensure proper interlocking throughout their lengths.

- a. Maintain driving hammers in proper alignment during driving operations by use of leads or guides attached to the hammer. [Caution must be taken in the sustained use of vibratory hammers when a hard driving condition is encountered to avoid interlock-melt or damage. Stop using vibratory hammers and impact hammers when the penetration rate due to vibratory loading is 300 mm less than one foot per minute.]
- b. Use a protecting cap when using impact hammers to prevent damage to the tops of pilings. [Use cast steel shoe to prevent damage to the tip of the sheet piling. Submit pile shoe installation details and material data for Government review and approval prior to use in the field.] Remove and replace pilings damaged during driving or driven out of interlock at no additional cost to the Government. [Store Government furnished pilings, damaged during driving, as directed.]
- c. Drive pilings without the aid of a water jet [unless otherwise authorized]. [Perform authorized jetting on both sides of the pilings simultaneously; discontinue jetting when the pile tip is approximately 1.5 m 5 feet above the ["calculated"] [indicated] pile tip elevation and make the final 1.5 m 5 feet of penetration by driving. Before commencing the driving of the final 1.5 m 5 feet, firmly seat the pile in place with reduced energy hammer blows.]
- d. Take adequate precautions to ensure that pilings are driven plumb. Where possible, drive Z-pile with the ball end leading. If an open socket is leading, a bolt or similar object placed in the bottom of the interlock will minimize packing material into it and ease driving for the next sheet. If the forward or leading edge of the piling wall is found to be out-of-plumb, in the plane of the wall, the piling being driven must be driven to the required depth and tapered pilings must be provided and driven to interlock with the out-of-plumb leading edge or other approved corrective measures taken to ensure the plumbness of succeeding pilings. The maximum permissible taper for any tapered piling is 10 mm per meter 1/8 inch per foot of length.
- e. Pilings in each run or continuous length of piling wall must be driven alternately in increments of depth to the required depth or elevation. Do not drive piling to a lower elevation than those behind it in the same run except when the pilings behind it cannot be driven

deeper. Incrementally sequence driving of individual piles so that the tip of any sheet pile is not more than 1.2 m 4 feet below that of any adjacent sheet pile. When the penetration resistance exceeds five blows per 25 mm inch, the tip of any sheet pile must not be more than 0.6 m 2 feet below any adjacent sheet pile.

- f. If obstructions restrict driving a piling to the specified penetration, the obstructions must be removed or penetrated with a chisel beam. If the Contractor demonstrates that removal or penetration is impractical, make changes in the design alignment of the piling structure as directed to ensure the adequacy and stability of the structure. Pilings must be driven to depths indicated and must extend up to the elevation indicated for the top of pilings. [Piling driven to rock must be seated individually on the rock.] A tolerance of [_____] mm inches above the indicated top elevation will be permitted.
- g. Pre-augering or spudding of piles [may be used at no additional cost to the Government] [is prohibited]. [Discontinue pre-augering or spudding approximately [_____] meters feet above the [calculated] [indicated] pile tip elevation. Drive the pile the final [_____] meters feet of penetration].
- h. If a void is left in stiff clay type soils, the void must be filled appropriately. The functional requirements of the wall and the soil conditions will determine if the backfill method will be bentonite slurry mix, sand, or earthen material to close the small void.

3.2.3 Cutting-Off

Pilings driven to refusal or to the point where additional penetration cannot be attained and are extending above the required top elevation in excess of the specified tolerance must be cut off in a manner recommended by the manufacturer to the required elevation. Do not drive pilings below the required top elevation.

- a. The tops of pilings excessively battered during driving must be trimmed when directed, at no additional cost to the Government. Piling cut-offs [except for Government furnished pilings] will become the property of the Contractor and must be removed from the site.
- b. Cut holes in pilings for bolts, rods, drains or utilities neatly, as indicated or as directed. Bolt holes in piling must be drilled by approved methods which will not damage the pile. Holes other than bolt holes must be reasonably smooth and the proper size for rods and other items to be inserted.

3.2.4 Inspection of Driven Piling

Perform continuous inspection during pile driving. Inspect all piles for compliance with tolerance requirements. Bring unusual problems which may occur to the attention of the Contracting Officer. Inspect the interlocked joints of driven pilings extending above ground. Pilings found to be out of interlock must be removed and replaced at no additional cost to the Government. [Use divers to inspect underwater interlocked joints of cofferdam sheet piling. Government divers may also inspect the interlocked joints. The inspection of cofferdams must be performed after driving is completed, prior to filling each cell and connecting arc, and within 48 hours after filling each cell and arc.]

3.2.5 Pulling and Redriving

NOTE: In general pulling of [PVC] [FRP] sheet piles is discouraged.

Submit a [pulling and redriving plan](#), a proposed method of pulling sheet piling, prior to construction. Pull, as directed, selected pilings after driving to determine the condition of the underground portions of pilings. Any piling so pulled and found to be damaged, to the extent that its usefulness in the structure is impaired, must be removed and replaced at no additional cost to the Government. Pilings pulled and found to be in satisfactory condition by the Contracting Officer must be redriven when directed. [Government furnished pilings pulled and not redriven must be stored as directed.]

When used for seepage cutoff, piles must maintain mechanical interlock throughout their alignment. When out-of-interlock piles cannot be pulled to reestablish interlocks, repair methods such as overlapping of piles and grout columns must be designed to provide an equivalent barrier. Remedial measures such as this must be designed by a Professional Engineer and submitted for approval.

[3.2.6 Testing Agency Qualifications

Engage an independent testing agency qualified in accordance with [ASTM C1077](#) and [ASTM E329](#) for the testing indicated, as documented according to [ASTM E548](#), and approved by the Contracting Officer.

]3.2.7 Survey Data

After the driving of each pile group is complete and before superimposed concrete is placed, provide the Contracting Officer with an [as-driven survey](#) showing the actual location and top elevation of each pile. Submit an as-driven survey showing actual location and top elevation of each [production pile] [test pile] within [7][_____] calendar days of completing the pile installation. Do not proceed with placing concrete until the Contracting Officer has reviewed the survey and verified the safe load for the pile group driven. Present a survey in such form that it gives deviation from plan location in two perpendicular directions and elevations of each pile to the nearest [13 mm half inch](#). The survey must be prepared and certified by a professional registered land surveyor licensed in the State of [_____].

3.3 DRAINAGE

NOTE: Include this paragraph in cases where sheet pile walls are not designed to retain saturated soils and drainage behind the sheet pile wall is required.

Backfill material behind the sheet piling must be free-draining and in accordance with Section [31 00 00 EARTHWORK](#). [Install drainage system and weep holes as indicated.]

3.4 REMOVAL

The removal of sheet pilings consists of pulling, sorting, cleaning the interlocks, inventorying, and storing previously installed sheet pilings as indicated and directed.

3.4.1 Pulling

NOTE: In general pulling of [PVC] [FRP] sheet piles is discouraged as it is likely that the pile will break. Generally the best way to safely remove [PVC] [FRP] is to trench to the bottom and remove the sheet; however, consideration should be given to other proposed methods as well.

The method of pulling piling must be approved. Provide pulling holes in pilings, as required. Extractors must be of suitable type and size. Exercise care during pulling of pilings to avoid damaging piling interlocks and adjacent construction. If the Contracting Officer determines that adjacent permanent construction has been damaged during pulling, then repair the damaged construction at no additional cost to the Government. Pull pilings one sheet at a time. Pilings fused together must be separated prior to pulling, unless the Contractor demonstrates, to the satisfaction of the Contracting Officer, that the pilings cannot be separated. The Contractor will not be paid for the removal of pilings damaged beyond structural use due to proper care not being exercised during pulling.

3.4.2 Sorting, Cleaning, Inventorying, and Storing

Pulled pilings must be sorted, cleaned, inventoried, and stored by type into groups as:

- a. Piling usable without reconditioning.
- b. Piling requiring reconditioning.
- c. Piling damaged beyond structural use.

3.5 INSTALLATION RECORDS

Maintain a **pile driving record** for each sheet pile driven. Indicate on the installation record: installation dates and times, type and size of hammer, rate of operation, total driving time, dimensions of driving helmet and cap used, blows required per **meter foot** for each **meter foot** of penetration, final driving resistance in blows for the final **150 mm 6 inches**, pile locations, tip elevations, ground elevations, cut-off elevations, and reheading or cutting of piles. Record unusual pile driving problems during driving. Submit complete records to the Contracting Officer.

3.6 VIBRATION CONTROL

NOTE: Include this paragraph when vibration monitoring is required. Add any additional criteria or requirements as necessary to the particular

project.

Perform vibration monitoring at the locations [indicated] [decided by the Contracting Officer] during the pile driving operations. Perform vibration monitoring [using] [seismographs][and geophones] within a distance of 61 meters 200 feet from the pile driving activity. [Engage the services of a qualified, independent Vibration Consultant, acceptable to the Government, to conduct the vibration monitoring. The Vibration Consultant must have a minimum of [five] years of experience in vibration monitoring. A minimum of [28] days before the installation of vibration monitors, submit to the Government the name of the Vibration Consultant and a list of at least [three] previously completed projects of similar scope and purpose.]

3.6.1 Monitoring

Prior to the pile driving activities, obtain baseline readings of ambient vibrations. The vibration during the pile driving activities must be limited to [a peak particle velocity of not more than 5 cm 2 inches per second] [the limits mentioned in the [Contract Documents]]. [Determine appropriate vibration limits in accordance with [U.S. Bureau of Mines] [American Association of State Highway and Transportation Officials (AASHTO)] guidelines.]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 Contracting Officer] are on-site to observe the structures nearest to the vibration monitor that has exceeded the limits.

3.6.2 Damage Responsibility

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

3.7 NOISE CONTROL

NOTE: Include this paragraph when noise monitoring is required. Add any additional criteria, references or requirements as necessary to the particular project.

Perform noise monitoring at the locations [indicated] [decided by the Contracting Officer] [at noise-sensitive public areas] during the pile driving operations. [Perform noise monitoring using [noise meters][, and][_____]]. [Engage the services of a qualified, independent Noise Consultant, acceptable to the Government, to conduct the noise monitoring. The Noise Consultant must have a minimum of [five] years of experience in noise monitoring. A minimum of [28] days before the installation of noise monitors, submit to the Government the name of the Noise 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

noise levels. [The noise limits are mentioned in the [Contract Documents]]. [Determine appropriate noise limits in accordance with [local agency] [U.S. Occupation Safety and Health Administration] guidelines].

3.7.1 Monitoring

During pile driving activities, monitor the noise to ensure the limits are not exceeded. If the limits are exceeded, cease the pile driving activity and install noise mitigation measures.

3.7.2 Damage Responsibility

The Contractor is responsible for damage resulting from the pile driving operations and must take the measures necessary to maintain noise within the specified limit. After completion of the project, remove the noise monitors from the site and from Government property, and restore the monitoring locations back to their original condition.

3.8 CONSTRUCTION INSTRUMENTATION AND MONITORING PROGRAM REPORT

NOTE: Include this section if instrumentation is to be installed due to concerns about vibration, settlement, lateral movement, etc. during pile driving activities. Instrumentation should be specified and included in the specification. This section can be deleted if there are no instrumentation requirements. Add any additional criteria or requirements as necessary for the particular project.

Prepare a Geotechnical Instrumentation Program to monitor 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 noise and vibration monitoring in accordance with paragraphs NOISE CONTROL and VIBRATION CONTROL.]

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 pile driving activities. Establish limiting values of vertical [and horizontal] movement [and angular distortion] [and vibration] for each structure and utility within the zone of influence, subject to review by the Government.

3.8.1 Reporting Requirements

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 the 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 data reports at least [_____] days 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 --