

550 Driven Piles

550.1 Description

- (1) This section describes providing steel piles, cast in place concrete piles, and precast concrete piles; providing test piles; driving piles; and determining required driving resistance. This section also describes preboring or re-driving.

550.2 Materials

550.2.1 Steel Piles and Pile Shells

- (1) Submit a certified report of test or analysis as specified in [506.3.21](#) at or before pile delivery unless the engineer directs or allows otherwise. Ensure that piles have marks tying them to a specific test report, or absent marks, certify that all material furnished is represented by a submitted test report. Provide marks or certifications for each piece of a pile fabricated from multiple pieces.
- (2) For HP sections, use [ASTM A572](#) grade 50 steel unless the plans show otherwise. If the engineer allows, the contractor may substitute steel pipe or steel oil field pipe for HP piles. Use pipe with an outside diameter of 7 3/4 inches or greater, a wall thickness of 3/8 inch or greater, and a cross-sectional area that equals or exceeds 97 percent of the area of the HP section replaced.
- (3) For steel pipe sections and steel pile shells for cast-in-place concrete piles, use [ASTM A252](#) grade 3 steel.
- (4) For steel oil field pipe sections, use [ASTM A252](#), Grade 3 steel with a maximum tensile strength of 85,000 psi. At or before delivery, certify the pipe's chemical composition and ensure that its carbon equivalency (CE) does not exceed 0.50 calculated as follows:

$$CE = C + (Mn + Si + Cr + Mo + V) / 6 + (Ni + Cu) / 15$$

- (5) Ensure that each individual oil field pipe delivered to the project conforms to the bill of lading and is marked to uniquely identify the load with a marking that is durable and legible. Use oil field pipe delivered in a magnetized condition for non-welded applications only.

550.2.2 Cast in Place Concrete Piles

- (1) Furnish materials conforming to the following:

Concrete grade A.....	501
Steel reinforcement.....	505
Steel pile shells.....	550.2.1
Steel shell end plates.....	506.2.2.2

- (2) The department will accept concrete by certification as specified for class III ancillary concrete in [716](#).
- (3) Ensure that steel pile shells have a minimum nominal wall thickness of 0.219 inches unless the plans or special provisions specify otherwise. Use seamless cylindrical tubes or cylindrical tubes with a straight or spiral welded seam.
- (4) Ensure that shell end plates are 3/4 or more inches thick, and have an outside diameter that does not exceed the pile outside diameter by more than 3/4 inch unless the plans show otherwise. Also ensure that shell end plate welds are watertight.

550.2.3 Precast Concrete Piles

- (1) Furnish materials for precast concrete piles as specified for I-type girders in [503.2](#) modified as follows:
 1. Use air-entrained concrete for piles unless the contract specifies otherwise.
 2. Provide 28-day compressive strength of 6000 psi unless the contract specifies greater strength.
- (2) Construct precast concrete piles conforming to [503.3.2](#) and [503.3.3](#) to plan dimensions within the following tolerances:

Cross-sectional dimensions.....	+/- 1/8 inch
Chamfers, miters, bevels, and radii.....	+/- 1/8 inch
Pre-stressing steel location.....	+/- 1/8 inch
Length.....	+/- 1/8 inch per 10 feet of length, not to exceed +/- 1/2 inch
Variation from true plane along the long axis.....	+/- 1/8 inch per 10 feet of length, not to exceed +/- 1/2 inch
- (3) Transport, handle, and store to prevent damage. Do not deliver to the job site until the piles have developed their full design strength. Support during transport at designated lifting or supporting points or provide additional support as the fabricator recommends. Lift at points the plans show using fabric or braided wire rope slings or other device that will not damage the pile surface or corners. Store on supports positioned, at a minimum, at designated lifting or supporting points.

550.2.4 Pile Points

- (1) Furnish commercially manufactured pile points from the [APL](#).

550.3 Construction

550.3.1 General

- (1) Use only one type of pile throughout a structure unless the plans show or the engineer allows otherwise.
- (2) Coordinate pile driving operations to prevent damage or displacement of concrete in substructure units. Do not drive test or production piles until excavation for that unit is complete. Remove material after driving piles as required to reestablish the correct elevation within the substructure footing limits before placing concrete.
- (3) Drive piles with a variation of 1/4 inch or less per foot from the vertical or from the batter the plans show. Ensure that trestle bent piles, concrete encased pile bents, and piles within mechanically stabilized earth walls are within 3 inches of the plan position after driving and that pile cap placement does not adversely affect pile resistance. Ensure that other piles are within 6 inches of the plan position after driving. Do not damage piles attempting to correct for misalignment.
- (4) Drive piles continuously to the required driving resistance, and if the plans show, to or beyond the required minimum tip elevation. Do not suspend driving operations for more than 3 hours without the engineer's approval.
- (5) Drive piles in pile groups starting at the center of the group and proceeding outward in both directions, or start at the outside row and proceed progressively across the group. Re-drive piles pushed up 0.25 inch or more using engineer-approved equipment and methods.
- (6) Remove and replace or otherwise correct piles the engineer deems unacceptable under [105.3](#). Causes for rejecting a pile include but are not limited to the following:
 - Piles placed out of position or misaligned vertically by more than the specified tolerance.
 - Piles with damage such as bends, breaks, kinks, deformation, cracking, or spalling resulting from internal defects, improper handling, or improper driving.
- (7) Submit details of planned corrections to the engineer for review and approval before initiating any corrective action.

550.3.2 Ordering Piles

- (1) Pile lengths the plans show are approximate. Furnish piles long enough to obtain the required driving resistance the plans show for each pile. Furnish test piles of the length the plans show. Order production piles based on test pile driving results.

550.3.3 Required Lengths

550.3.3.1 Steel Piles and Pile Shells

- (1) Furnish steel HP, steel pipe, and steel oil field pipe sections 20 feet or shorter with no splices. For piles greater than 20 feet long through 50 feet long, furnish piles with no more than two shop or field splices. For piles greater than 50 feet long, furnish piles with no more than four shop or field splices.
- (2) Furnish steel pile shells 50 feet or shorter with no more than three shop or field splices. For piles greater than 50 feet long, furnish piles with no more than four shop or field splices.
- (3) The contractor may extend piles with 5-foot or longer field cutoffs to provide the additional length needed to achieve required driving resistance.

550.3.3.2 Precast Concrete Piles

- (1) Furnish precast concrete piles 60 feet or shorter with no splices. For piles greater than 60 feet long through 120 feet long, furnish piles with no more than one splice. For piles greater than 120 feet long, conform to splicing requirements the plans show or special provisions specify.

550.3.4 Splices

550.3.4.1 Steel Piles and Pile Shells

550.3.4.1.1 General

- (1) Conform to splice details the plans show. If substituting pipe or oil field pipe for HP piles, submit proposed splicing details to the engineer for approval. Ensure that splices transfer the full pile or pile shell strength in compression, tension, and bending. Ensure that pile shell splices are watertight. Except as allowed for oil field pipe, do not use mechanical splices.
- (2) Weld splices conforming to the AWS D1.1/D1.1M Structural Welding Code-Steel. Use shielded metal arc welding (SMAW) for welds on portions of piles that will be above grade in service.

- (3) Submit an annual field welding plan conforming to [CMM 520.6.5.4](#) on department form [DT2337](#). Do not begin field welding without a department-approved welding plan that includes the specific welding procedures required to perform the work under the contract.
- (4) Visually inspect and certify the quality of field welds as follows:
 1. Designate an inspector listed in the contractor's current approved field welding plan.
 2. Have the designated inspector complete department form [DT2320](#) for each day of field welding and submit to the engineer for inclusion in the permanent project record.

550.3.4.1.2 Steel Oil Field Pipe Piling

- (1) Position backup rings flush with the joint and place according to AWS D1.1/D1.1M Structural Welding Code-Steel. Ensure that the rings allow the joint to contract freely as the weld cools. Make tack welds the smallest size necessary to hold the pipe ends in alignment for welding.
- (2) For materials not listed in table 3.1 of the AWS D1.1 code, preheat for a distance of 5 inches on both sides of the weld as follows:
 - CE less than 0.35: heat to 100 F.
 - CE greater than or equal to 0.35 and less than or equal to 0.45: heat to 175 F.
 - CE greater than 0.45 and less than or equal to 0.50: heat to 300 F.
- (3) Protect the pipe ends from high winds and precipitation during welding.
- (4) If the engineer approves, the contractor may use threaded or mechanical splices.

550.3.4.2 Precast Concrete Piling

- (1) Conform to splice details the plans show.

550.3.5 Driving Equipment

550.3.5.1 General

- (1) Furnish a pile driving system capable of driving piles to the required driving resistance with a minimum blow count of 30 blows/foot and with a minimum rated hammer energy of 12,500 ft-lbs.
- (2) The engineer will determine if the contractor's equipment is capable of driving piles to the required driving resistance and tip elevation. Do not drive piles until the engineer approves the driving equipment.
- (3) Use an engineer-approved pile driving system. Submit department form [DT3550](#) to the engineer at least 30 days before driving piles. Resubmit [DT3550](#) if proposing changes to a previously approved pile driving system.
- (4) The engineer may order the contractor to remove pile driving system components from service if they cause insufficient energy transfer or damage the pile. Do not return a component to service until the engineer determines that it has been satisfactorily repaired or adjusted.

550.3.5.2 Hammers

- (1) Drive piles with diesel, air, steam, gravity, or hydraulic hammers. Do not use vibratory hammers unless the engineer approves. Re-strike piles driven with vibratory hammers with an impact hammer to determine the required driving resistance.
- (2) Ensure that single acting diesel hammers are configured to accurately determine hammer stroke visually during driving. Provide a hammer manufacturer's chart equating stroke to equivalent energy.
- (3) Ensure that double acting diesel hammers have a bounce chamber pressure gauge easily read from ground level. Provide a chart, calibrated to actual hammer performance, certifying the bounce chamber pressure that equates to either equivalent energy or stroke. At the beginning of pile driving, provide a hammer calibration chart that is less than 90 days old and recalibrate and provide a new certified chart at least every 90 calendar days during driving operations.
- (4) Ensure that air, steam, or hydraulic hammers and associated equipment can maintain the manufacturer's specified volume and pressure under working conditions and have easily accessible pressure gauges. Also ensure that the hammer striking parts of air or steam hammers weigh at least 2750 pounds and exceed the weight of the helmet plus pile being driven.

550.3.5.3 Hammer Cushions

- (1) For impact driving systems designed to use hammer cushions, provide cushions thick enough to prevent hammer or pile damage and ensure uniform driving behavior. Use materials conforming to the hammer manufacturer's specifications except do not use wood, wire rope, or asbestos. Use a manufacturer recommended striker plate to ensure uniform compression within the cushion. Remove the cushion for engineer inspection when project pile driving begins and after each 100 hours of driving. Replace when the cushion is less than 75 percent of its original thickness.

550.3.5.4 Helmets

- (1) Use lead-guided helmets to distribute hammer blows to the pile head while maintaining axial alignment between the hammer, helmet, and pile. Do not use free-swinging helmets.

550.3.5.5 Pile Cushions

- (1) Use a new plywood, hardwood, or composite plywood/hardwood cushion to protect the head of each pre-cast concrete pile. Provide 4-inch or thicker cushions shaped to match the top of the pile. Replace when less than 50 percent of its original thickness or if it begins to burn. Submit requests to use cushions made of materials other than wood to the engineer for review and approval.

550.3.5.6 Leads

- (1) Provide either fixed or swinging leads with all pile hammers. Ensure that leads give the hammer freedom of movement while maintaining a concentric impact under each hammer blow.
- (2) Rig swinging leads to maintain axial alignment between the hammer line of travel and pile. Maintain alignment during driving using braces or other supports and provide a pile gate at the bottom of the leads.
- (3) Unless driving piles through water, use leads long enough to preclude the need for followers.

550.3.5.7 Followers

- (1) If driving piles through water and if the engineer allows, the contractor may use followers to drive the pile to the required depth or elevation. Ensure that using followers does not damage the piles.

550.3.5.8 Water Jets

- (1) If the contract allows or engineer approves, the contractor may use water jets for end bearing piles. Use enough jets with enough water volume and nozzle pressure to freely erode material next to the pile without affecting lateral stability of the completed pile. Use equipment capable of operating two 3/4-inch nozzles simultaneously with 100 or more psi pressure at each nozzle.

550.3.6 Driving Resistance

- (1) Drive piles to the depths necessary to obtain the required driving resistance as determined by the modified Gates formula as follows:

$$P = (0.875 \times E^{1/2} \times \log(10/s)) - 50$$

where:

P = Nominal resistance in tons.

E = Energy produced by the hammer per blow in foot-pounds.

s = Average penetration in inches per blow for the final 10 to 20 blows.
For piles driven to a predominantly end bearing condition, compute over a maximum distance of 1 inch.

- (2) If the plans show a minimum tip elevation, drive to that elevation even if required driving resistance is achieved sooner. Drive beyond that elevation if necessary to also achieve required driving resistance.

550.3.7 Pile Redriving

- (1) Under the Pile Redriving bid item, drive 15 percent of the piles in each substructure unit to plan length or to the required driving resistance whichever occurs sooner. If required driving resistance is not obtained in the plan length, allow the pile to set up for 24 hours or more, then restrike. Determine the required driving resistance using the first 10 hammer blows during restrike. If required driving resistance is still not obtained, splice on additional length if needed, and drive the pile an additional 10 feet, or to the depth the engineer directs, and restrike after allowing the pile to set up for another 24 hours or more. Repeat this process until the required driving resistance is obtained. After obtaining the required driving resistance, drive the other piles in the substructure to the same tip elevation.
- (2) Restrike with the same pile driving system used to drive the production piles. Warm up the hammer by striking another pile a minimum of 20 blows before restriking.

550.3.8 Test Piles

- (1) Drive test piles at locations the plans show to both the required driving resistance, and if the plans show, to the required minimum tip elevation. Complete excavation for the associated substructure unit before driving test piles. Use the same driving system as will be used to drive the production piles. Do not drive any production piles for the associated substructure unit until all test piles are driven.

550.3.9 Pre-Boring

550.3.9.1 General

- (1) Pre-bore holes to the depth the plans or special provisions require. Submit written requests for pre-boring not required under the contract to the engineer for review and approval. Do not impair the capacity of in-place piles or damage adjacent structures by pre-boring operations.

550.3.9.2 Pre-Boring in Unconsolidated Materials

- (1) For round piles, pre-bore holes of approximately the pile diameter. For other shapes, pre-bore holes of a diameter approximately equal to the greatest diagonal pile section dimension. Increase the diameter as necessary for pile installation if subsurface obstructions are encountered.
- (2) Maintain an open hole for pile installation using temporary casing if necessary. Do not remove casing until the pile is placed in the pre-bore hole. After driving, backfill around the pile with sand or other engineer-approved material and dispose of excess material.

550.3.9.3 Pre-Boring in Rock or Consolidated Materials

- (1) For round piles, pre-bore holes at least one inch larger than the pile outside diameter. For other shapes, pre-bore holes at least one inch larger than the greatest diagonal pile section dimension.
- (2) Case holes as necessary to prevent introduction of unconsolidated material. Seat the casing firmly into the rock or consolidated material surface. Clear debris from the pre-bore hole before installing the pile.
- (3) Firmly seat piles after preboring and backfill within the rock or consolidated material with a cement grout. Remove the casing, backfill the piles with sand or other engineer-approved material, and dispose of excess material.
- (4) Do not blast without the engineer's approval.

550.3.10 Pile Points

- (1) Attach pile points conforming to the manufacturer's instructions unless the plans show otherwise.

550.3.11 Finishing Piles

550.3.11.1 General

- (1) Cut off piles to a true plane at the plan elevation. Cut off pile shells for cast-in-place concrete piles before placing concrete. Pile cut-offs become the contractor's property.
- (2) For steel oil field pipe piles, remove soil, water, and other materials within the pile to the bottom of the footing elevation. Fill any void below this elevation with engineer-approved material or install a barrier acceptable to the engineer at or below this elevation.

550.3.11.2 Cast-in-Place Concrete

- (1) Remove water or other foreign material from inside shells before placing concrete. Do not place concrete under freezing conditions without the engineer's approval.
- (2) Place steel reinforcement as the plans show ensuring that it is in the correct location when the level of concrete placement reaches the lower limits of that reinforcement.
- (3) After the engineer inspects and approves the pile shells, deposit the concrete in each shell in a continuous operation at a rate that causes no air pockets or cold joints. For pile shells with an inside diameter greater than 16 inches, place concrete with a tremie or downspout within the shell. Fill the shell completely with concrete and consolidate to a depth as great as practicable with a mechanical vibrator or by other engineer-approved method.
- (4) Do not place concrete in shells that are within a 15 feet radius of other shells not yet driven. If this requirement cannot be met, suspend pile driving operations until minimum concrete cures times are met or minimum compressive strengths are achieved. If using high early strength concrete, the minimum cure time is 3 days. If using a grade A concrete the minimum cure time is 7 days. If using strength, do not resume driving until achieving a compressive strength of 2500 psi or more, determined as specified in [502.3.4.2](#).

550.3.11.3 Painting

- (1) Use a paint system from the [APL](#). Paint steel piles that are exposed in the completed work from the top of the pile to 4 feet or more below the streambed or ground line. Ensure that painted areas are fully cured before driving.
- (2) Prepare the surface and apply paint as specified in [517](#), except blast clean conforming to SSPC-SP10.
- (3) Handle painted piling with padded slings, nonmetallic slings, or softeners to minimize paint damage. Repair damaged paint exposed above either the water or ground line.

550.4 Measurement

- (1) The department will measure the Piling bid items by the linear foot acceptably completed, measured as the length of piling driven and left in place below the cutoff elevation.
- (2) The department will measure Pile Points as each individual point acceptably installed.
- (3) The department will measure the Pre-Boring bid items by the linear foot acceptably completed, measured from the footing base to the depth the plans show or engineer directs.
- (4) The department will measure Pile Splices Precast Concrete as each individual splice acceptably completed. The department will not measure splices for production or test piles fabricated to plan length or more than 1 splice per 20 linear feet of pile length in excess of the plan length.
- (5) The department will measure Pile Redriving as each individual restrrike acceptably completed. There may be multiple restrikes per pile.

550.5 Payment

550.5.1 General

- (1) The department will pay for measured quantities at the contract unit price under the following bid items:

<u>ITEM NUMBER</u>	<u>DESCRIPTION</u>	<u>UNIT</u>
550.0010	Pre-Boring Unconsolidated Materials	LF
550.0020	Pre-Boring Rock or Consolidated Materials	LF
550.0500	Pile Points	EACH
550.0600	Pile Redriving	EACH
550.1100 - 1500	Piling Steel HP (size)	LF
550.2100 - 2500	Piling CIP Concrete (size) (shell thickness)	LF
550.3100 - 3500	Piling Precast Concrete (size)	LF
550.3810 - 3816	Pile Splices Precast Concrete (size)	EACH

- (2) Payment for the Pre-Boring bid items is full compensation for drilling the pre-boring holes; for providing and removing casing; and for backfilling. The department will not pay for pre-boring the contract does not require or for repairing damage to adjacent structures caused by the contractor's pre-boring operations.
- (3) Payment for Pile Points is full compensation for providing and attaching pile points.
- (4) Payment for Pile Redriving is full compensation for restriking as required to measure the driving resistance including associated delay, movement of equipment, and mobilization costs.
- (5) Payment for the Pile Splices Precast Concrete is full compensation for providing field splices.

550.5.2 Piling

- (1) Payment for the Piling bid items is full compensation for providing piles; for driving piles; for cutting off piles; for re-driving heaved up piles; for concrete; for painting; and for excavating material within the footing perimeter heaved up by pile driving operations.
- (2) Except for precast concrete piles, the department will pay the contract price for 9 feet of HP piling or 6 feet of other piling types for splices under the Pile Splices administrative item. The department will not pay for splices made between the pile tip and the plan length. For splices made beyond the plan length, the department will pay for a maximum of one splice for each 30 feet or fraction of 30 feet beyond plan length. The department will only pay for splicing if piles conform to the following:
 - 1. The required driving resistance cannot be achieved in the length the plans show.
 - 2. Splices conform to the contract.
 - 3. The spliced pile is acceptably driven to the plan required driving resistance.
- (3) The department will not entertain a change order request for a differing site condition under [104.2.2.2](#) or for a quantity change under [104.2.2.4.3](#) for the Piling bid items. Instead the department will adjust pay under the Piling Quantity Variation administrative item if the total driven length of each size is less than 85 percent of, or more than 115 percent of the contract quantity as follows:

<u>PERCENT OF CONTRACT LENGTH DRIVEN</u>	<u>PAY ADJUSTMENT</u>
< 85	(85% contract length - driven length) x 20% unit price
> 115	(driven length - 115% contract length) x 5% unit price