

## Section 705. FOUNDATION PILING

**705.01 Description.** This work consists of furnishing and driving timber piles, cast-in-place concrete piles, and steel piles. The following definitions shall apply:

**Minimum Pile Length.** The length between pile cutoff elevation and minimum pile penetration elevation shown on the plans.

**Estimated Pile Length.** The length shown on the plans to be used as a guide for estimating the work and ordering test piles in cases where the dynamic formula is specified.

**Test Pile.** A pile driven at a location shown on the plans to determine pile driving characteristics.

**Ordered Pile Length.** The length determined from test pile results. For timber piles the determination will be made by the Engineer. For cast-in-place concrete piles and steel piles, the determination shall be made by the Contractor.

**Design Pile Length.** The predetermined length specified on the plans for piles.

**Practical Refusal.** A bearing value of 150 percent of the required bearing determined by the dynamic formula specified in subsection 705.03.F.

**Absolute Refusal.** A bearing value of 200 percent of the required bearing determined by the dynamic formula specified in subsection 705.03.F.

**C-I-P.** CIP when used in conjunction with this section will designate Cast-in-Place.

**705.02 Materials.** Materials shall meet the following requirements.

Concrete, Grade S1 .....	701
Mortar and Grout .....	702
Granular Material, Class II .....	902
Steel Reinforcement .....	905
Foundation Piles .....	906
Water .....	911
Treated Timber Piles .....	912

Steel piles shall consist of structural steel shapes of the section provided on the plans or by authorization. Steel piles shall be either new or used in good condition.

### 705.03 Construction.

- A. **Equipment.** Pile hammers shall be supported in leads. Leads shall allow the hammer free movement and shall be rigged to hold the pile and hammer in alignment during driving. The piles shall be driven with equipment which will ensure an evenly distributed hammer blow on the pile and prevent damage while driving.

Drop hammers will not be permitted for driving permanent piling.

Pile hammers shall have a minimum rated energy of not less than 13,000 foot-pounds per blow. The Contractor shall furnish an operator's manual and manufacturer's specifications for the hammer proposed for use.

Pile hammers shall be equipped with a suitable bonnet or cap which will accurately and securely hold the top of the pile in correct position with reference to the hammer and distribute the blow from the ram over the entire top area of the pile.

- B. **Test Piles.** When the design pile length is shown on the plans, test piles will not be required. Before driving test piles, the excavation or embankment shall have been completed to within 2 feet of the proposed grade at the places where the test piles are driven. The test piles shall be driven first to the minimum pile length or to practical refusal, whichever penetration is greater.

When test piles are called for, the ordered pile lengths shall be determined from the test pile results. The ordered pile lengths for timber piles will be determined by the Engineer. The Contractor shall be entirely responsible for furnishing cast-in-place concrete pile shells and steel piles of sufficient lengths to obtain the specified bearing capacity and penetration for each pile.

- C. **Load Testing.** Load tests shall be performed when specified in the contract documents. When load testing is specified, the detailed requirements will be given in the proposal.
- D. **Pile Preboring.** When specified, holes will be prebored to the elevation shown. The diameter of the finished hole shall be equal to or slightly greater than the diameter of the pile.

The Contractor shall maintain a stable open hole until the pile has been installed and advanced to the bottom of the bore. Final drive for bearing will not begin until the pile reaches the prebore elevation. Caving or unstable soil layers will be controlled through the use of temporary casing or non-toxic and non-hazardous drilling slurry. Drilling slurry, if used, will be handled and disposed of according to the Sedimentation and Erosion Control Act (PA 347 of 1972 as amended) either on the site or at an off site location where existing or proposed structures will not be affected. Any on site disposal must be approved by the Engineer.

Boulders, cobbles, or other obstructions shall be removed or otherwise cleared. The Contractor shall provide rock chisels, extractors, core barrels, or any other equipment necessary to clear obstructions. The removal of obstructions that require this special equipment will be paid for as extra work.

To the extent possible, all preboring within a foundation unit will be completed, and all piles advanced to the prebore elevation, before final drive begins. When preboring occurs within 20 feet of a completed pile, the pile shall be rechecked for capacity by restrrike. The Engineer will select the piles for restrrike. Restrikes shall be performed with the same driving equipment used in the initial installation. If any reduction in capacity occurs, all piles shall be redriven to design bearing.

All voids remaining after the final drive shall be backfilled with granular material Class II or approved equal.

Prebored pile holes shall be constructed with a variation of not more than ¼ inch per foot from the vertical or from the batter line shown on the plans. Upon completion, the center of the hole at cutoff elevation shall be within 6 inches of the position shown on the plans.

#### E. Driving Methods.

1. **General.** Piles shall be driven only after the excavation is complete, and where piles are to be driven through fills, they shall not be started until the embankment has been compacted to the bottom of the concrete substructure unit. Pile driving will not be permitted within a radius of 25 feet of newly placed concrete until the concrete has attained at least 75 percent of its specified minimum strength. All piles for a given foundation unit shall be driven with the same hammer, under the same operating conditions, and with the same cushion material as was used to drive the test piles.

Shells for cast-in-place piles shall be of watertight construction, so that the concrete may be placed in the dry. The Contractor shall have available at all times a mirror and a light suitable for illuminating the interior of the pile shells for their full length after being driven. Any pile shell showing bends, kinks, or other deformations incurred during the process of driving, that would impair the strength of the completed pile as determined by the Engineer, shall be replaced without any additional cost to the Department. Replacement shall consist of pulling the damaged shell and driving a new shell in the same location or of driving a new shell near the damaged shell at a location approved by the Engineer. When the damaged shell is left in place, it shall be filled with concrete.

Treated timber piles shall be handled carefully to avoid bruising or injuring their surfaces. They shall not be handled by tongs, cant hooks, or pike poles. Full length timber piles shall be used, and they shall not be driven with a follower, except where otherwise provided on the plans or by authorization.

2. **Obstructions.** If an impenetrable obstruction is encountered when driving a pile the Contractor will have the option to choose either of the following courses of action:
  - a. The pile may be removed, and if found to be reusable by the Engineer, adjusted laterally (side to side), and redriven. The requirements of subsection 705.03.E.5 will apply to the redriven pile except for the lateral adjustment from the plan location allowed here. The Contractor will be paid for the total length of pile driven which will include the length of pile that was embedded in the ground and removed.
  - b. The pile may be cut-off at the lowest practical elevation and another pile adjusted laterally (side to side) and driven. The requirements of subsection 705.03.E.5 will apply to the driven pile except for the lateral adjustment from the plan location allowed here. The Contractor will be paid for the total length of pile driven which will include the length of pile that was cut-off and left in the ground.

If the Contractor is unable to bypass the impenetrable obstruction using either course of action, then the obstruction shall be removed or otherwise cleared. The Contractor shall provide rock chisels, extractors, core barrels, or other equipment necessary to clear obstructions. The removal of obstructions that require this special equipment will be paid for as extra work.

3. **Penetration.** When the design pile length is specified on the plans, the piles shall be driven to the design pile penetration, unless absolute refusal is reached at some depth less than the design pile penetration but greater than the minimum pile penetration.

When the estimated pile length is specified on the plans, the piles shall be driven to the specified bearing resistance but not less than the minimum pile penetration.

Methods used to advance the piles beyond absolute refusal, if required to attain penetration determined necessary by the Engineer, will be considered extra work. The method used for advancing the pile beyond absolute refusal shall be discontinued 3 feet from the final tip elevation unless otherwise directed by the Engineer.

4. **Splicing.** Steel piles and steel pile shells may be furnished in full length sections or they may be spliced according to the method of splicing shown on the plans or approved by the Engineer. There is no limit to the number of splices that may be used per pile. Splicing of timber piles will not be allowed.

Welding shall be according to subsections 707.03.D.8.b, c, and d. Welded splices for piles shall be made only by qualified welders using E6010 electrodes. E7015, E7016, or E7018 electrodes may be used provided the AWS requirements for storage and use are met.

5. **Accuracy.** Piles for foundation work shall be driven with a variation of not more than  $\frac{1}{4}$  inch per foot from the vertical or from the batter line shown on the plans. After driving, the position of each pile at cutoff elevation shall be within 6 inches of the position shown on the plans except that the distance between the edge of any pile and the outline of the superimposed concrete shall be not less than 9 inches.

All piles shall be cut off normal to the longitudinal axis of the pile. Cut off shall be within one inch of the elevation specified. Piles capped above grade shall be driven with such accuracy that they can be adjusted to the positions and elevations shown on the plans without damaging or overstressing the piles.

Timber piles shall be driven with such accuracy that they can be adjusted to the true position shown on the plans at the elevation of cap or wale without damaging or overstressing the pile. Piles to be capped shall be drawn and held in proper position before cut off to one plane. When the pile cutoff diameter is greater than the width of the cap, the pile shall be trimmed to eliminate horizontal projection outside the cap.

Timber piles shall not be driven to the exact grade but shall be cut off below the tapered head so that the bearing will be on the unfractured, full cross section of the pile.

6. **Redriving.** Piles heaved up during driving of adjacent piles shall be redriven to the required bearing capacity or penetration. Any upheaval or settlement of material between the piles during driving shall be adjusted to the correct elevation before concrete for the foundation is placed.

F. **Determination of Bearing Value.** When the bearing value is to be computed by pile penetration, the following dynamic formula shall be used:

$$P = \frac{2.5 E C}{S+0.1}$$

where:

$$C = \frac{W_r + k^2 W_p}{W_r + W_p}$$

P = Bearing value in pounds.

S = The average penetration in inches per blow for the last 10 blows of the hammer.

W<sub>r</sub> = Mass of striking parts of hammer (ram) in pounds.

W<sub>p</sub> = Mass of parts being driven and includes the anvil (if any), driving helmet, driving cap, mandrel, pile weight, etc., in pounds .

k = Impact loss coefficient based on properties of the hammer cushion material. The following values will be used for these representative cushioning materials:

0.68 Aluminum

0.66 Cast Polyamide/Nylon

0.64 Phenolic Laminates/Micarta

0.58 Kevlar Laminates

Other cushioning materials shall be approved by the Engineer.

E = Manufacturer's rated maximum energy expressed in foot-pounds and subject to the following conditions:

When using a close-top type of diesel hammer, the maximum equivalent energy is to be used in calculating bearing only when the hammer is on the verge of "floating" atop the pile. If this floating action is unattainable, the Contractor shall furnish an instrument to measure the bounce chamber pressure and resulting hammer output.

When using double-acting or differential-acting steam (air) hammers, the dynamic formula is applicable only when the required pressure specified by the manufacturer is delivered at the hammer. When the pressure at the hammer is below that specified, the energy will be adjusted downward using the following relationship before calculating the bearing value where:

$$E = H(Wr + Ap)$$

- H = Height of fall in feet.
- Wr = Mass of striking parts of hammer (ram) in pounds.
- A = Area of piston, in square inches, for double-acting hammers (smaller piston for differential-acting hammers).
- p = Steam (air) pressure at the hammer in pounds per square inch.

G. **Placing Concrete and Reinforcing Steel in Cast-in-Place Concrete Piles.** After the steel shells are in place and approved by the Engineer, they shall be filled with concrete. For piles 60 feet or more in length, approximately 2 cubic feet of Type R-2 mortar shall be placed in the bottom of the steel shell before placing the concrete. Concrete placement shall conform to subsection 706.03.H, except that concrete may be allowed to freefall more than 5 feet.

No concrete shall be placed in any pile until all piles within a radius of 20 feet have been driven, redriven (if necessary) and accepted, and until the shell has been thoroughly cleaned of any water or debris. The concrete shall be placed in the pile shells to the cutoff elevation as soon after driving as permissible. The piles shall be filled so as to avoid honeycomb and air pockets in the concrete. During placing operations, the concrete in the upper one third of the pile shell, but not to exceed 25 feet, shall be vibrated to consolidate the concrete without causing segregation. Piles containing steel reinforcement shall be vibrated internally for the entire depth of the steel cage.

H. **Protective Coating for Steel Piles and Steel Pile Shells.** Steel piles and steel pile shells that will be exposed to air or water in the finished structure shall be galvanized according to ASTM A 123.

Embankment within 30 feet of piles shall not be corrosive material.

I. **Cleaning Steel Piles and Steel Pile Shells.** Where steel piles or pile shells are to be embedded one foot or more in structural concrete, exclusive of tremie concrete, the portion to be embedded shall be cleaned of all dirt and loose scale.

J. **Treating Timber Piling.** A minimum of three coats of preservative according to subsection 912.04 shall be brushed on the tops of treated piling and on cuts or holes above water level.

**705.04 Measurement and Payment.**

<b>Contract Item (Pay Item)</b>	<b>Pay Unit</b>
Pile, Treated Timber, Furn .....	Foot
Pile, Treated Timber, Driven .....	Foot
Pile, CIP Conc, Furn and Driven, ___ inch .....	Foot
Pile, Steel, Furn and Driven, ___ inch .....	Foot
Pile, Galv .....	Lump Sum
Test Pile, Treated Timber .....	Each
Test Pile, CIP Conc, ___ inch .....	Each

Test Pile, Steel, ___ inch .....	Each
Pile Point, CIP Conc .....	Each
Pile Point, Steel .....	Each
Prebore, Fnd Piling .....	Foot
Pile Driving Equipment, Furn .....	Lump Sum

A. **Pile, Treated Timber, Furn** will be paid for at the ordered pile length.

**Pile, Treated Timber, Driven** will be measured by length of piling left in place below cutoff.

Cutoff of piles will not be paid for separately. Cutoff material will remain the property of the Contractor.

B. **CIP Conc and Steel Piles. Pile, CIP Conc, Furn and Driven, and Pile, Steel, Furn and Driven**, will be measured by length of all piling left in place below cutoff. This length will include the length of pile that was embedded in the ground, and then removed, in attempting to bypass an impenetrable obstruction. Cast-in-place concrete piles and steel piles will not include the length of the pile point extending beyond the pile. Piling may be furnished in any desired length and field spliced as necessary to provide sufficient length to obtain required bearing or penetration.

**Pile, Galv** will include only the cost associated with galvanizing the required length of pile as detailed on the plans. The cost of furnishing the ungalvanized pile shells or steel piles, and the cost of driving the galvanized pile length will be included in the pay item **Pile, CIP Conc, Furn and Driven**, or **Pile, Steel, Furn and Driven**.

If steel shells other than the minimum gauge specified are required to obtain penetration, they will be paid for as extra work.

C. **Pile Driving Equipment**. Furnishing and removing equipment for driving piles will be included in the pay item **Pile Driving Equipment, Furn**. Equipment operating costs for driving piles will be included in the bid item for length of pile driven.

**Pile Driving Equipment, Furn** will be measured as a unit for each structure.

D. **Foundation Piling Prebore. Prebore, Fnd Piling** will be measured by length. Length will be computed from the bottom of the foundation to the prebore elevation shown on the plans. This item includes boring of pile holes, disposal of excavated material, backfill of any void space, installation and removal of temporary casings, furnishing and disposal of drilling slurry, restriking of completed piles within a radius of 25 feet and operating costs for equipment.

When **Prebore, Fnd Piling** is a bid item on the plans, furnishing equipment for prebore shall be included in the bid item **Pile Driving Equipment, Furnished**. Preboring not shown on the plans, when authorized by the Engineer in writing, will be paid for as extra work.

Jetting, when not shown on the plans but authorized in writing by the Engineer, will be paid for as extra work.

- E. **Pile Points** will not be paid for separately unless they are a contract item. Payment for such work is included in the contract unit prices bid for other contract items.
- F. The contract unit price for **Test Piles** shall be in addition to the contract unit price(s) for piles furnished and driven.
- G. Splices will be included in payment for the pile furnished and driven.