500 STRUCTURES

ITEM 507 - BEARING PILES

507.01 Description. *This work consists of furnishing and driving bearing piles.*

507.02 General. *Install piles of the specified type, length, and sizes shown on the plans. Furnish the piles according to the itemized order list shown on the plans. If additional length is needed to obtain bearing, furnish the additional length as determined by the Engineer. The length of the piles given in the order list is not necessarily based on available or practical lengths, but the estimated length from the bottom of each pile to the elevation of the cutoff. The Contractor may increase or decrease the pile lengths to suit the lengths available, to facilitate the method of operation, which may involve provided fresh heading as a result of hammer misalignment or a worn hammer cushion, or to provide lengths determined practical to have delivered to the project site and driven.*

To help determine the required lengths of the piles, the Contractor may drive piles, make borings, or conduct such other investigations as he considers necessary, at no additional expense to the City.

507.03 Materials. Materials shall conform to the following:

Concrete (Class C)..	511
Reinforcing steel	509
Chemical admixture for concrete, Type F	705.12
Steel *H*-piles	711.01 or 711.03
Timber	711.26
Steel pile points	711.01 or 711.07

Galvanized steel 711.02

The material properties for the metal shells of cast-in-place reinforced concrete piles are not specified. Provide mill certifications showing domestic origin.

Provide a concrete slump from 6 to 8 inches (150 to 200 mm) with the use of a superplasticizer.

507.04 Driving of Piles. *Drive piles to refusal on bedrock; until obtaining the required ultimate bearing value (R), which may include a modification for scour, set-up, or negative skin friction; or to the minimum penetration pile tip elevation shown on the plans.*

If bearing capacity is obtained before the pile has penetrated 80 percent of its estimated depth, notify the City before appreciably overdriving the pile. The City will study the conditions and determine the final penetration, the driving requirements, the use of another pile type, and the use of prebored holes.

If embankment material makes it difficult to obtain adequate pile penetration, the use of prebored holes at the Contractor's expense will be permitted.

All piles raised during the process of driving adjacent piles shall be driven down again.

Select a hammer compatible with the driving conditions. Using the formula in 507.05, select a hammer that will achieve the required ultimate load for the pile with a blow count from 30 to 75 blows per foot (100 to 240 blows per meter). The Contractor may use a hammer that requires a blow count in excess of 65 blows per foot (216 blows per meter) provided the Contractor sets up and runs a dynamic pile test at his expense. The results of this test shall only be used for the structure at which the test was performed and only to the bearing tested. Additional tests shall be required if the contractor proposes to use a hammer in which the blow count exceeds 65 blows per foot (216 blows per meter) on different structures or for different bearing on the same structure as previously tested. Additional test shall also be required if the contractor switches hammers.

The ram of an air-operated or diesel hammer shall weigh at least 2700 pounds (12,000 N). The ram of a drop hammer for permanent piles shall weigh at least 3,000 pounds (13,300 N). The Contractor may use a drop hammer with a minimum weight of 2000 pounds (9000 N) for temporary piles if the constant used in the capacity formula of 507.05 is 0.5 (12.7) instead of 0.3 (7.62). The height of fall for drop hammers shall not exceed 7 feet (2.1 m). Do not use drop hammers to drive piles that are to be driven to an ultimate load in excess of 70 tons (620 kN).

When using open ended diesel hammers, provide equipment for the Engineer's use to accurately measure each stroke within 6 inches (0.15m).

Attach a gage to closed end diesel hammers, accessible to the Engineer, to monitor the pressure in the bounce chamber. Include a graph with the gage to convert pressure to energy.

Attach an impact energy monitor to hydraulic hammers, accessible to the Engineer, to monitor the energy of each blow.

When the outside rows of bearing piles are not driven accurately, the size of the footing shall be increased at the Contractor's expense, so that the minimum thickness of concrete between any pile and the edge of the footing will be at least 75 percent of that shown on the plan.

Use securely anchored driving leads and a cap device with sliding jaws to engage the leads to guide the pile and maintain the pile alignment with the stroke of the hammer. Accurately align the travel of the hammer with the axis of the pile.

Cushion the hammer and pile to prevent the impact of driving forces from damaging the top of the pile. Shape the cap and pile top to uniformly distribute the hammer blow to the top surface of the pile.

A follower shall not be used without permission of the Engineer, but when approved for use, an allowance shall be made for the increased energy loss.

If a static load test is required, the Contractor may not drive piles except the test and anchor piles before conducting the test and the required depth of penetration has been determined.

Do not use water jets.

Piles which become damaged during driving shall be replaced or repaired.

After being driven, cut off the piles at the elevation and angle shown on the plans.

507.05 Determination of Capacity. *The Engineer will determine the ultimate bearing value (R) of a driven pile as if the pile was a single isolated pile using the following capacity formula or the formula as modified based on static load test or a dynamic load test results. If a pile begins to crush, immediately cease pile driving and repair or replace the pile. The counting of blows will cease until the crushed pile is either repaired or replaced.*

For drop hammers:

$$R = \frac{4DWH}{S + 0.3} \qquad \left(R = \frac{3276DWH}{S + 7.62} \right)$$

$$B = \frac{12}{\left(\frac{4DWH}{R}\right) - 0.3} \qquad \left(B = \frac{1000}{\left(\frac{3276DWH}{R}\right) - 2.54}\right)$$

For an air-operated, hydraulic, or diesel hammers:

$$R = \frac{XDF}{S + 0.1} \qquad \left(R = \frac{XDF}{S + 2.54}\right)$$

$$B = \frac{12}{\left(\frac{XDF}{R}\right) - 0.1} \qquad \left(B = \frac{1000}{\left(\frac{XDF}{R}\right) - 2.54}\right)$$

In which:

X = 2.7 (224) for diesel hammers.

X = 3.2 (267) for air-operated hammers.

X = 4 (334) for hydraulic hammers.

R = Ultimate bearing value, in pounds (Newtons), corresponding with the ultimate load capacity per pile shown on the plans.

B = Blows per foot (meter).

$D = \frac{1 - UG}{\sqrt{1 + G^2}}$ (applies only in case of battered piles) For vertical piles, D = 1.

W =Weight of the ram or striking parts of hammer, in pounds (kilograms)

H = Height of fall of the ram or striking parts, in feet (meters)

F = Manufacture's rated energy for an air operated, hydraulic, or closed end diesel hammer, in ft-lbs (joules).

F = W H for open ended diesel hammers

S = Penetration, in inches (millimeters) per blow generally determined from the rate of penetration for the last several inches (millimeters) of penetration.

U = Coefficient of friction, which is estimated at 0.05 for double-acting, differential-acting, air operated, or diesel hammer, 0.1 for single-acting air operated or diesel hammer, and 0.2 for drop hammers.

G = Rate of batter (1/3, 1/4, etc.)

Q = Ultimate bearing value, in pounds (Newtons), determined according to a 506 or 523 test.

After an interruption in pile driving, if rate of penetration immediately after the interruption is appreciably less than before the interruption and if approved by the City, the Contractor may use the value of S determined immediately after the interruption in the capacity formula.

If R of a driven pile, checked by static or dynamic load tests according to 506 or 523, is different than R determined by the capacity formula, modify the capacity formula

by multiplying the specification formula coefficients of X (for air operated hydraulic or diesel hammers) and the coefficients of 4 (3276) (for drop hammers) by the ratio Q/R. Use the modified formula to determine R of bearing piles of the same type and size and that penetrate for nearly the same depth into substantially the same kind of soils. Adjust the formula as necessary if pile-driving conditions change from the conditions at the test pile.

507.06 Cast-in-Place Reinforced Concrete Piles. Provide cast-in-place reinforced concrete piles conforming to one or more of the types described below: Measure the pile diameter as follows:

(a) Plain cylindrical casing, the outside diameter.

(b) Cylindrical casings with vertical fluting, the diameter of a circle circumscribing the outermost points or ridges.

(c) Cylindrical casing with circumferential corrugations, the average of the outside diameters measured at the bottom and top of the corrugations or continuously welded helical corrugations with diameters measured at the tops of the corrugations.

(d) Tapered piles, the top diameters as determined in (a), (b), or (c), but the *pile tip diameter* shall not be less than 8 inches (200 mm).

Pile casings shall be water-tight after being driven. If furnished, shoes or points shall not project more than 1/4 inch (6 mm) outside the vertical surface of the casing.

For plain cylindrical casings, the minimum pile wall thickness (t) is the greater of 0.179 inches (4.77 mm) or the thickness determined using the following formula:

$$t\ (\text{in inches}) = \frac{R}{1070000} \qquad \left(t\ (\text{in mm}) = \frac{R}{187376} \right)$$

For monotube piles, the minimum pile wall thickness shall be t/1.4 where t is determined by the above formula.

The Contractor shall have available a suitable light for the inspection of a driven casing for its entire length.

After installation, cover the tops of driven casings until the concrete is placed. Before placing concrete, remove accumulated water or other foreign matter in a driven casing. Maintain a minimum radius of 15 feet (4.5 m) between simultaneous work of placing concrete and driving pile casings. If concrete is placed within the 15-foot (4.5 m) radius, suspend driving operations until the concrete has cured for 5 days. Place concrete

for cast-in-place piles using methods that prevent voids, however, do not vibrate the concrete.

507.07 Steel *H*-Piles. Steel *H*-piles shall consist of structural steel shapes of the kind and size specified.

The Engineer may allow installation of steel piles, which the Contractor has from previous projects or stock, if the Contractor furnishes mill certifications and the pile sections are identified with the material specification number, grade, and heat number. This identification may be in the form of information painted on the steel piles or a tag physically attached to the steel.

507.08 Timber Piles. Provide timber piles of sufficient length to remove broomed or split portions caused by driving. Symmetrically trim piles right truncated cone at the tip. If steel shoes or points are specified, carefully shape the tip of the pile so that the steel shoe or point fits snugly and symmetrically.

Handle and store timber piles to prevent warping.

If specified, provide creosoted piles conforming to 712.06.

507.09 Splices. *To the fullest extent practical, avoid splicing steel casings and structural shapes. Splice pile casings and structural shapes either before or after driving a segment. If spliced after driving a segment, splice the piles at least 3 feet (0.9 m) above the ground and inspect the splice while the pile is driven a minimum of 150 blows.*

Align segments to splices to provide one axis for the pile .

Use full penetration butt welds to splice structural shapes according to 513.21 except delete the requirement to use temporary extension bars.

The Contractor may furnish longer or shorter steel piles than in the itemized order list shown on the plans.

Do not splice timber piles.

507.10 Defective Piles. *Piles entirely underground are defective if the pile location at the ground surface is more than the 1 foot (0.3 m) from the location shown on the plans.*

Piles projecting above the ground are defective if the pile location at the ground surface is more than 3 inches (75 mm) from the location shown on the plans. Pipe piles are defective if not water tight or if damage reduces the cross sectional area by more than 20 percent. Provide the Engineer with a light that allows inspection of the entire length of the interior of a driven casing casing.

Replace, repair, or drive a substitute pile beside the defective pile. The location tolerance for underground piles does not apply to substitute piles beside defective underground piles. The off-location limits do apply to the substitute pile which project above the ground. If a defective pile is removed, fill the hole remaining in the ground with sand. Cut off a defective pile left in place under a footing 3 inches (75 mm) above the elevation of the bottom of the footing. Cut off a defective pile left in place but not under a footing at least 1 foot (0.3 m) below ground level. Fill defective pipe piles left in place with concrete.

When the outside rows of bearing piles are not located within tolerances specified above, increase the size of the footing to provide a minimum distance between the pile and footing edge of at least 75 percent of that shown on the plans.

507.12 Prebored Holes. Locate prebored holes as shown on the plans. Provide augured hole diameters as follows: (1) for round piles, from 2 inches (51 mm) less to 4 inches (102 mm) more than the pile diameter, (2) for steel H-piles, from 6 inches (151 mm) less to 2 inches (51 mm) more than the pile's diagonal dimension but shall be such as to produce satisfactory pile driving results. Backfill voids between the pile and the prebored rehole with a granular material satisfactory to the Engineer.

507.13 Method of Measurement. *The Engineer will measure piles driven by the number of linear feet (meters). The Engineer will determine the sum as the lengths of all non-defective piles measured along the axis of each pile from the bottom of each pile to the elevation of cutoff. Unless a separate pay item is specified in the contract, the Engineer will include Steel Points or Shoes in the measured length of driven piles. If a separate pay item is specified in the contract, the Engineer will measure Steel Points or Shoes by the number of each.*

The Engineer will measure piles furnished by the number of linear feet (meters) of plan specified order length plus any additional order length specified by the Engineer.

The Engineer will include the length of undriven piles as furnished, but the Contractor will not receive additional compensation for hauling the piles off the project.

For plan specified prebored holes, the Engineer will measure Prebored Holes by the number of linear feet (meters) of prebored hole lengths for non-defective piles measured from the surface of ground at the time of boring to the bottom of the hole. The Engineer will not measure preboring to facilitate the pile driving operation.

The Engineer will measure steel pile splices by the number of splices authorized by the Engineer to lengthen non-defective piles beyond the plan specified length. Instead of plan specified steel pile splices, the Contractor may choose to furnish either steel piles longer or shorter than the plan specified pile order lengths. The Engineer will not measure any splices due to the Contractor furnishing pile lengths shorter than plan order lengths.

507.15 Basis of Payment. The Engineer will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
507	Linear Foot (Meter)	Steel Piles, HP ___ X ___, Furnished
507	*Linear Foot (Meter)*	*Steel Piles, HP ___ X ___, Driven*
507	Linear Foot (Meter)	____ "(___mm) Cast-in-Place Reinforced Concrete Piles, Furnished
507	*Linear Foot (Meter)*	*____ "(___mm) Cast-in-Place Reinforced Concrete Piles, Driven*
507	Linear Foot (Meter)	Timber Piles, Creosoted
507	Linear Foot (Meter)	Timber Piles, Untreated
507	Linear Foot (Meter)	Prebored Holes
507	Each	Steel Points or Shoes

Preboring to facilitate the pile driving operation is included in the unit price bid for piles driven. The Engineer will not pay for any splices due to the Contractor furnishing pile lengths shorter than plan order lengths.

The Engineer will not pay for increased pile lengths made by the Contractor unless the Engineer determines that the additional lengths are needed to achieve bearing.