

SECTION 502

DRIVING PILES

502.1 GENERAL

The driving of piles will comply with the specifications contained in this section. The type and location of piles to be installed shall be shown on the construction plans. The specifications for the various types of piles are included in Sections 150, 151, and 152.

502.2 REFERENCES

This Publication:

SECTION 150

SECTION 151

SECTION 152

502.3 INSTALLATION

502.3.1 Piles driven under this specification shall be accurately spaced and driven either vertically or to the prescribed batter, as indicated on the plans; no greater variation from the vertical or specified batter line than 1/4 of an inch per foot of length being permitted. Piles otherwise driven and those seriously damaged in driving shall be removed or cut off and replaced with new piles. Should any pile be raised by the subsequent driving of others, it shall be re-driven.

502.3.2 The pile top elevations shown on the plans are approximate and are to be used as a basis for establishing quantities for piling, including exploratory piles, for bidding purpose only.

502.3.3 When required in the Supplementary Specifications, one pile of the type selected or designated for the work shall be driven in each pier and abutment area as an exploratory pile. The location of these piles shall be determined by the ENGINEER.

502.3.4 The conditions under which the exploratory piles will be driven shall be as ordered by the ENGINEER. These exploratory piles shall be furnished and driven by the CONTRACTOR and under normal circumstances shall be left in place and utilized as one of the specified piles.

502.3.5 Exploratory piles shall be driven with the same size and type hammer operating with the same effective energy and efficiency as that to be used in driving the remainder of the piles.

502.3.6 The purpose of driving the exploratory piles is to determine the length and penetration that will be required in the balance of the piles. Therefore, no

piles other than the exploratory piles shall be driven at each pier or abutment area until such determination has been made by the ENGINEER and has been reported to the CONTRACTOR.

502.3.7 The ENGINEER shall order the top elevation to which the piling shall be driven for the particular pier or abutment. All piles shall be driven to the top elevation as established by the ENGINEER or deeper if necessary to develop the prescribed bearing value as determined by the formula hereinafter prescribed.

502.3.8 Required excavations in the areas through which the piles are to be driven shall be made before any pile is driven therein. NO excavation may be made below the bottom of the pile footing elevation, unless approved by the ENGINEER.

502.3.9 When piles are to be driven through bridge approach embankment and the depth of the embankment at the pile location is in excess of 5 feet, the pile shall be driven in a hole drilled through embankment. The hole shall have a diameter of not less than the butt diameter of the pile plus 6 inches. After driving the pile, the annular space around the pile shall be filled to ground surface with dry sand or pea gravel.

502.3.10 No piles shall be driven within 25 feet of any concrete that has not attained a minimum compressive strength of 2000 psi.

502.4 PILE DRIVING EQUIPMENT AND OPERATIONS

502.4.1 No piles shall be driven, no piles shall be jetted, and no pile holes shall be drilled unless the ENGINEER is present during the operation.

502.4.2 All piles shall be protected during driving with an approved driving head. The tops of timber piling shall be trimmed to fit the driving head, and the piles shall be protected against brooming and splitting. Timber piles shall be pointed (4 inches square point) or shod with metal shoes when required. A cushion block approved by the ENGINEER shall be used. In case the metal pile top folds, corrugates, or is otherwise damaged due to impact of the hammer blow, the CONTRACTOR may be required to reinforce the top of the pile.

502.4.3 Unless otherwise provided, bearing piles shall be driven with a pile hammer delivering not less

than 15,000 foot pounds of energy per blow, except timber piling may be driven with drop hammers or pile hammers having an energy rating not less than 6,800 foot pounds. Pile hammers shall be operated at speeds recommended by the manufacturer.

502.4.4 Gravity hammers for timber piles shall weigh approximately 3,000 pounds, except that the hammer shall not weigh more than 3,500 pounds. The maximum drop shall not exceed 10 feet. When the hammer fails to produce the required bearing, the ENGINEER may permit 5 blows at not to exceed 36,000 foot pounds of energy per blow as a final check of bearing obtained. The CONTRACTOR shall furnish the ENGINEER with a certified scale weight of the hammer to be used. Steam, air, or diesel hammers for driving timber piling shall develop an energy of not less than 6,800 foot pounds of the manufacturer's rated energy.

502.4.5 Pile driver leads shall be constructed so as to afford freedom of movement to the hammer and shall be held firmly in position by guys, stiff braces, or other effective method to prevent swinging and to support the pile in driving and insure the hammer blow being delivered squarely on the end of the pile. When driving batter piles, the lead shall be inclined and effectively braced so as to remain in line with the desired position of the pile. The driving of piles by the use of followers will not be permitted without written permission of the ENGINEER.

502.4.6 When approved by the ENGINEER, the CONTRACTOR may supplement driving equipment with a water jetting plant without extra compensation. The number of jets and the volume and pressure of water at the jet nozzle shall be sufficient to freely erode the material adjacent to the pile. The plant shall have a sufficient capacity to deliver at all times at least 325 g.p.m at 100 pounds pressure per square inch at two 3/4 inch nozzles. Before the desired penetration is reached, the jets shall be withdrawn and the pile shall be driven by the manner to obtain the final penetration and bearing.

502.4.7 Piles shall be driven to not less than the minimum penetration elevation shown on the plans, unless otherwise permitted by the ENGINEER. Piling shall be driven to at least the design bearing shown on the plans, unless otherwise directed by the ENGINEER. Timber piling shall not be driven to a computed bearing in excess of 50 tons.

502.4.8 When approved by the ENGINEER, water jets or drilling may be used in conjunction with the hammer to obtain the specified penetration. If

possible, the last 3 feet of penetration shall be obtained by driving without the use of water jets.

502.4.9 Test blows, to determine average penetration, shall be applied after the jets have been removed. The use of water jets will not modify any of the requirements of this section.

502.4.10 Unless drilled holes are shown on the plans, holes other than starting holes shall not be drilled until the ENGINEER has determined that piling cannot be driven, except where piling is to be placed in compacted fill at abutments.

502.4.11 When permitted by the ENGINEER, pilot holes may be drilled to an elevation sufficient to allow driving the pile to at least minimum penetration elevation, but not more than full specified length, providing that such may be accomplished without injury to the pile and full bearing is achieved. Where piling is to be placed in compacted fill at abutments, when permitted by the ENGINEER, pilot holes may be drilled to the natural ground elevation prior to attempting to drive the piling. All drilled pilot holes will be considered incidental to the completion of the work and no measurement or payment will be made therefore.

502.4.12 The drilling of holes shall be done by approved methods and in such manner that the piles will be accurately positioned as shown on the plans.

502.4.13 Unless larger hole is permitted by the ENGINEER to obtain minimum penetration, the diameter of the drilled holes shall not exceed the following:

502.4.13.1 Timber Piles--One inch larger than the average between the tip and butt diameters.

502.4.13.2 Pipe Piles--The outside pile diameter.

502.4.13.3 "H" Piles--Two inches smaller than the diagonal measurement of the pile.

502.4.14 When a pile is set in a hole larger than the diameter of the pile, the portion of the hole in solid material shall be filled with Class A concrete and the portion of the hole above solid material may be filled with sand or other suitable material. These materials will be considered incidental to the completion of the work and no direct payment will be made therefore.

502.4.15 The ENGINEER shall make an inspection to determine if shooting with explosives or redesign is necessary when piles cannot be driven or holes drilled. Shooting of holes with explosives will not be allowed without written permission.

502.4.16 Driven pilot holes may be used to loosen and break up the compacted strata to such an extent that the piles may be driven to the required depth through the driven pilot holes.

502.4.17 Abutment bearing piles shall not be driven until the approach embankment material, underneath and adjacent to the abutment, has been placed and compacted to the required density. The surface of such approach embankment, after compaction, shall be not less than the elevation of the bottom of the abutment.

502.4.18 When steel pipe piling are included in the work, the CONTRACTOR shall have available at all times a suitable device, of a type approved by the ENGINEER, for thoroughly illuminating the interior of the pipe piles for their entire length after they have been driven. Any pipe pile that shows breaks, deformations, or other defects that would impair the strength or efficiency of the completed pile shall be pulled or abandoned if approved by the ENGINEER and replaced at the CONTRACTOR's expense.

502.4.19 After steel pipe piles have been driven to final penetration, such piles will be given a final inspection. Any water or other foreign substance inside the piles shall be removed. Upon approval of the driven piles by the ENGINEER, such piles shall be filled with concrete. The initial deposit in the pipe shall be 2 or 3 cubic feet of Portland cement mortar, which shall be followed by deposits of concrete in layers not more than 3 feet in depth and each layer shall be compacted by rodding or by other approved methods before a succeeding layer is placed. The work of placing and compacting the concrete shall be carried on continuously in successive layers until the entire pipe pile is completely filled. The schedule for driving piles shall be such as to avoid vibrations and pressure reaching piles or other structural components in which concrete has been placed and taken initial set but has not attained sufficient strength to resist damage.

502.5 COMPUTATIONS FOR BEARING VALUES

502.5.1 In the absence of loading tests, the bearing value of a pile will be determined as herein provided. When required by the ENGINEER, a pile shall be left to set for a period not to exceed 24 hours and again driven to determine the safe bearing value.

502.5.2 Each structural steel pile, steel pipe pile, or timber pile driven without a core or mandrel shall have a bearing value determined as follows:

502.5.2.1 Gravity hammers:

$$P = \frac{2WH}{S + 1.0}$$

502.5.2.2 Single-acting steam, air, or diesel hammers having open ends:

$$P = \frac{2WH}{S + 1.0}$$

502.5.2.3 Double-acting steam, air, or diesel hammers having enclosed ends:

$$P = \frac{2E}{S + 1.0}$$

502.5.2.4 Where:

P = Allowable safe bearing value in pounds.

W = Weight in pounds of striking parts of the hammer.

H = Height of fall or stroke of the ram in feet.

E = Manufacturer's rated energy in foot pounds per blow at the rated speed for double acting steam or air hammers.

502.5.2.5 E = Ninety percent of the average equivalent energy in foot pounds as determined by a gauge attached to the hammer and recorded during the period when the average penetration per blow is recorded, for diesel hammers having enclosed rams.

Hammers of this type shall be equipped with a gauge and applicable charts supplied, which will evaluate the equivalent energy being produced under any driving condition, otherwise the formula for diesel hammers with open end will apply.

502.5.2.6 S = Average penetration in inches per blow during the last 10 to 20 blows.

502.5.3 Steel pile shells driven with a core or mandrel, the bearing value of a single pile will be determined by one of the formulas herein provided:

502.5.3.1 Single-acting steam, air, or diesel hammers having open ends:

$$P = \frac{2WH}{W} \quad S + \underline{0.1(w)}$$

502.5.3.2 Double-acting steam, air, or diesel hammers having enclosed ends:

$$P = \frac{2E}{W} \quad S + \underline{0.1(w)}$$

502.5.3.3 Where:

(w) = Weight of the pile including the weight of the core or mandrel in pounds.

502.5.4 The formulas in Subsections 502.5.2 and 502.5.3 are applicable only when:

502.5.4.1 The gravity hammer has a free fall.

502.5.4.2 The penetration is at a reasonably quick and uniform rate.

502.5.4.3 The lifting line on the hammer is slack so that the whole weight of the hammer is on the pile.

502.5.4.4 There is no appreciable bounce after the blow. Twice the height of the bounce shall be deducted from "H" to determine its true value in the formulas.

502.5.4.5 The head of a wood pile is free from broomed or crushed wood fiber.

502.5.4.6 A follower is not used.

502.6 TOLERANCES AND REJECTION

502.6.1 Piles, preparatory to driving, shall be located accurately in the correct position. During the driving, the pile shall be held in its correct position by adequately braced leads, a heavy template, struts, cables, toggles, or other approved methods.

502.6.2 Foundation piling shall be driven with a maximum variation of not to exceed 1/4 inch per foot from the vertical or from the batter shown, with the head of the pile varying not to exceed 6 inches from the plan position. These tolerances may be waived by the ENGINEER if, in his opinion, the conditions made such tolerances impractical and the capability of the structure is not impaired by exceeding the tolerances given. Foundation piling shall not be driven until after the excavation is approximately complete.

502.6.3 Trestle piling shall be driven with a maximum variation of not to exceed 1/4 inch per foot from the vertical or batter shown, with the pile varying not to exceed 3 inches from the plan position. These tolerances may be waived by the ENGINEER if, in his opinion, the conditions make such tolerances impractical and the capability of the structure is not impaired by exceeding the tolerances given.

502.6.4 Piles broken by reason of internal defects or by improper driving or driven out of the tolerances allowed will be rejected. When permitted by the ENGINEER, a second pile may be driven adjacent to

the rejected pile, provided such second pile is driven without detriment to the structure; otherwise the rejected pile shall be removed and replaced. The removing and replacing of a rejected pile or the furnishing and driving of a second pile adjacent to a rejected pile will be considered incidental to the completion of the work and no measurement or payment will be made therefore.

502.6.5 The tops of all piles shall be cut off normal to the pile or to the bevel shown on the plans and to the elevations established by the ENGINEER.

502.6.6 Structural steel piles and steel pipe piles shall be accurately cut off at the required elevation. Steel pipe piles shall be cut off before filled with concrete.

502.7 TIMBER PILES WITH TIMBER CAPS

Timber piles which support timber caps shall conform to the plane of the bottom of the superimposed cap. Wedging or shimming between the pile and cap will not be permitted. The heads of all treated and untreated timber pile for trestles, after driving and cutting off, shall be treated by either method herein provided. Heads of piling encased in concrete do not require either of the following treatments.

502.7.1 A coat of hot creosote oil shall first be applied to the head of the pile and a protective cap then built up by applying alternate layers of loosely woven fabric and hot asphalt or tar and 2 layers of fabric. The fabric shall measure 6 inches more in each direction than the pile diameter and shall be turned down over the pile neatly trimmed and the edges secured by binding with 2 turns of No. 10 galvanized wire. The fabric shall be wired in advance of the final coat of asphalt or tar which shall extend down over the wiring.

502.7.2 Three coats of hot creosote oil shall first be applied to the head of the pile followed by 1 coat of hot roofing pitch. Each coat shall be allowed to become practically dry before applying the succeeding coat. A covering of 20 gauge galvanized sheet metal shall be placed over the pitch coating. The cap material shall measure not less than 6 inches more in each direction than the diameter of the piling and shall be turned or bent down over the pile. The edges shall be neatly trimmed and secured to the pile with large-head galvanized nails.

502.8 STEEL PILE COLUMNS

Steel pile columns shall be placed in dug or drilled holes at locations, batters, and elevations shown on the plans. After placement, steel pipe pile columns

shall be filled with concrete and painted as herein provided:

502.8.1 Steel pile columns shall be set plumb or to the batter shown on the plans. Variation greater than 1/8 inch per foot from the vertical or batter line indicated will not be permitted. The top of the pile shall not be out of the position shown on the plans by more than 1 inch.

502.8.2 Closed-end pipe pile columns shall be placed to bear directly on the solid rock or shale at the bottom of the excavation. When required, a layer of Portland cement mortar shall be deposited on the bottom of the excavation on the cleaned surface of rock or shale to provide a full bearing for the closed end of the pipe. Mortar deposited under water shall be placed by means of a suitable tremie. In case the excavation is dry or is dewatered, open-end pipe pile columns may be used when approved by the ENGINEER. When open-end pipe pile columns are used, the top of the rock or shale at the bottom of the excavation shall be thoroughly cleaned before placing the columns.

502.8.2.3 After steel pipe pile columns have been placed in final position, they shall be given a final inspection. Any water or other foreign substance inside the pipe shall be removed. Upon approval by the ENGINEER, the pipes shall be filled with concrete. The initial deposit in the pipe shall be 2 or 3 cubic feet of Portland cement mortar, which shall be followed by deposits of concrete in layers not more than 3 feet in depth and each layer compacted by rodding or by other method satisfactory to the ENGINEER before a succeeding layer is placed. The work of placing and compacting the concrete shall proceed continuously in successive layers until the entire pipe is completely filled.

502.9 BEARING PILE LOAD TEST

502.9.1 General

When required, this work shall consist of a test load on a driven pile to determine the bearing capacity and settlement behavior of the pile. The pile load test shall be conducted under the supervision of the ENGINEER.

502.9.2 Test Methods

502.9.2.1. The CONTRACTOR shall apply the test load concentrically by such method that the test load acting on the pile may be accurately determined and controlled at any time. The CONTRACTOR shall

submit the method of anchorage and loading to the ENGINEER, for approval prior to beginning any test.

502.9.2.2 The CONTRACTOR shall furnish accurate gauges and devices for determining the load applied and shall furnish the ENGINEER with a certificate of calibration of the gauges or devices from an approved laboratory prior to use.

502.9.2.3 The CONTRACTOR shall furnish the ENGINEER with adequate facilities for making load and settlement readings 24 hours per day, except such engineering instruments and apparatus normally used by the ENGINEER.

502.9.2.4 The load shall be applied to the pile as near the ground surface as practicable or as designated by the ENGINEER. If the load is applied on a pile projecting appreciably above ground, care shall be taken to prevent failure by column action. Test piles shall be vertical within the tolerances provided. Test loading results will not be accepted when pile fails structurally during test loading due to faulty installation or procedure by the CONTRACTOR.

502.9.2.5 After load testing is completed, test piles and anchor piles shall be used as bearing piles, unless rejected by the ENGINEER. Rejected test piles and anchor piles shall be removed by the CONTRACTOR at his expense.

502.9.2.6 Test load shall be applied not less than 24 hours after test pile and anchor piles have been driven. When test loading pipe piles, the test piles and anchor piles shall not be loaded until the concrete has attained a compressive strength of not less than 2,400 psi. The ENGINEER may require all piles to be driven within the test area before the test pile is test loaded. The load shall be applied in increments as herein provided. The first load application shall be approximately 4/5 of the design bearing capacity in tons as shown on the plans. Additional load increments of 10 tons each shall be applied not less than 2 hour after all measurable settlement due to previous loading has been determined. Such load increments shall be applied, as herein provided, until the load test has been completed. Measurable settlement is defined as settlement of 1/8 inch or more subsequent to an intermediate reading.

502.9.2.7 Readings of the amount of settlement will be made by the ENGINEER immediately before and after the application of each load increment and at intermediate intervals 20 minutes apart. Such

readings and corresponding load increments and total load will be recorded.

502.9.2.8 The application of load will be considered complete when the gross settlement of the loaded pile reaches the yield point, except when the yield point is reached before the total load equals 1.6 times the design load of the pile as shown on the plans. Yield point is defined as when the additional amount of settlement exceeds 0.02 inch per ton for the increment applied. When this amount of settlement per increment occurs before the total load equals 1.6 times the design bearing capacity, an additional similar increment of load shall be applied to determine if this amount of settlement per increment is repeated or exceeded. If this amount of settlement per increment is repeated or exceeded, the application of load will be considered complete; but if not, the application of increments will be continued until yield point occurs or until the maximum amount of load required is applied.

502.9.2.9 The CONTRACTOR will not be required to apply a total load greater than 3 times the design bearing capacity in tons, unless otherwise shown on the plans or in the Supplementary Specifications.

502.9.2.10 When the yield point in the settlement has not been reached after the last increment of load required has been applied, the application of the total load shall be continued for not less than 12 hours after all measurable settlement has ceased.

502.9.2.11 Immediately after the total load is removed from the pile, the net settlement will be recorded by the ENGINEER. Not less than 3 hours after the total load is removed from the pile, the settlement will again be recorded by the ENGINEER.

502.9.2.12 When it becomes necessary, due to unforeseen conditions, to remove and reapply any of the test load, such application shall be made gradually in increments approved by the ENGINEER.

502.10 MEASUREMENT AND PAYMENT

Measurement and payment of the various items will be as follows:

502.10.1 Splices for structural steel piles, structural steel pile columns, steel pipe piles, and steel pipe pile columns will be considered incidental to the completion of the work and no measurement or payment will be made therefore.

502.10.2 Pile load tests will be measured as follows:

502.10.2.1 First pile load test.

502.10.2.2 Each subsequent pile load test.

502.10.3 All pile cut-offs will be considered incidental to the completion of the work and no measurement or payment will be made therefore.

502.10.4 Piles that have been driven or partially driven and subsequently ordered removed by the ENGINEER will be considered incidental to the completion of the work and no measurement or payment will be made therefore.

502.10.5 When drilled holes for bearing piles are called for on the plans, such drilled holes will be measured to the nearest vertical foot.

502.10.6 Metal shoes for timber piling, authorized by the ENGINEER and furnished by the CONTRACTOR, will be measured by the unit per each.

502.10.7 All jetting and all pilot holes will be considered incidental to the completion of the work and no measurement or payment will be made therefore.

502.10.8 Test piles driven and not included in the permanent structure will be measured to the nearest vertical foot. Payment will be made at the unit price per vertical foot per type of pile as indicated in the Bid Proposal.

502.10.9 Piles of approved length, furnished and not driven, will be measured to the nearest linear foot. Payment will be made at the unit price per foot per type of pile as indicated in the Bid Proposal.

502.10.10 All piles of the various types and lengths permanently incorporated in the structure will be measured to the nearest vertical foot after cut-off.

502.10.11 Concrete placed in steel pipe piles or steel pipe columns will be measured to the nearest 1/10 cubic yard. Payment will be made at the unit price per cubic yard as shown in the Bid Proposal.

502.10.12 Steel reinforcement placed in steel pipe piles or steel pipe columns will be measured by the pound. Payment shall be made at the unit price per pound as stated in the Bid Proposal.