

704 - PILING

SECTION 704

PILING

704.1 DESCRIPTION

Drive the specified types of piles to the penetration and bearing values shown in the Contract Documents.

BID ITEMS

UNITS

Piles (*) (**)	Linear Foot
Test Piles (*) (**)	Linear Foot
Test Piles (Special) (*) (**)	Linear Foot
Cast Steel Pile Points	Each
Pre-Drilled Pile Holes	Linear Foot
*Type of Pile or Test Pile: Cast-In-Place Concrete, Prestressed Concrete, Steel or Steel Sheet	
**Size	

704.2 MATERIALS

Provide materials that comply with the applicable requirements.

Concrete	DIVISION 400
Prestressed Concrete Piles	DIVISION 700
Steel Bars for Concrete Reinforcement	DIVISION 1600
Steel Piling and Steel Pile Points	DIVISION 1600
Type B Prefomed Expansion Joint Filler	DIVISION 1500
Paint Materials	DIVISION 1800

704.3 CONSTRUCTION REQUIREMENTS

a. Order Lists and Test Piles. Drive the specified test piles at the locations shown in the Contract Documents. The Engineer will use the test pile information to determine the length that remains in the completed structure and to determine order length of piles.

A restrike is required by the Engineer and is subsidiary to "Test Piles". Follow **subsection 704.3e.** for restrike procedures. Provide piles for the structure according to the order list (number and length of piles) prepared by the Engineer.

If test piles are not specified, the order list is the same as the estimated quantity (number and length of piles) shown in the Contract Documents.

Provide the Engineer with the completed "Pile and Driving Equipment Data" sheet a minimum of 3 weeks before the scheduled date of the Pre-construction Conference. The Engineer will forward this information to the State Geologist Office.

b. Test Pile (Special). Pile Driving Analyzer (PDA). The Engineer will use the PDA to monitor the driving of the test piles. Provide the Engineer with the completed "Pile and Driving Equipment Data" sheet a minimum of 3 weeks before the scheduled date of the Pre-construction Conference. The Engineer will forward this information to the State Geologist Office.

In order to mobilize the PDA, notify the Engineer a minimum of 5 working days before driving the test piles. Prior to driving the test pile, the Engineer will require approximately 1½ hours to prepare the test piling and install the dynamic measuring equipment. After the test pile is placed in the leads, provide the Engineer with safe and reasonable means of access to the pile for preparing the pile and attaching the instruments.

A restrike is required by the Engineer and is subsidiary to "Test Pile Special". Follow **subsection 704.3e.** for restrike procedures.

To obtain the estimated ultimate loads, the Engineer will use the PDA to take dynamic measurements as the test pile is driven to the required driving resistance. If non-axial driving is indicated by dynamic test equipment measurements, immediately realign the driving system. The Engineer will use the PDA results to provide the Contractor with a blow count for production driving.

704 - PILING

c. Driving Piles. Drive the piles with a gravity hammer, a diesel hammer, an air/steam hammer or a combination of pre-drilled holes or water jetting and a hammer. Use equipment that complies with **subsection 157.2**.

Drive the piles at the locations and to the vertical or battered lines shown in the Contract Documents. Use leads of sufficient length to allow them to be spiked into the ground at the onset of driving the pile.

Do not drive piles until the footing, webwall or abutment excavation is completed. Drive all of the piles required for the footing or abutment before placing any concrete in the footing or abutment, unless the foundation is a minimum of 20 feet away or has cured a minimum of 24 hours.

When specified, drill pile holes before driving the piles. Drill the holes accurately so that the piles are set as shown in the Contract Documents. The maximum size of the pre-drilled holes is equal to the diameter of the pile plus 3 inches. The depth of pre-drilled pile holes is shown in the Contract Documents. If pre-drilled pile holes are not specified, the Contractor may choose to pre-drill pile holes, provided the Engineer approves the Contractor's method and limits. After the piles are driven to their final positions in the pre-drilled holes, fill the holes with loose sand or material specified in the Contract Documents. If concrete is specified, allow sufficient concrete slump and provide vibration to fill all voids around the pile.

Drive all pile heads perpendicular to the longitudinal axis of the piles to prevent eccentric impacts from the drive head of the hammer. Use pile caps on all piles during the pile driving operations. For pile caps of concrete piles and prestressed concrete piles, use a suitable cushion next to the pile head that fits into a casting that supports a timber shock block. On pile caps for steel piles and steel sheet piles, provide grooves in the bottom of the cap to accommodate the shape of the piles to hold the axis of piles in line with the axis of the hammer.

If specified, use the type of cast steel pile points shown in the Contract Documents. Use pile points that provide full bearing for the piles. Provide an experienced welder to attach the cast steel pile points to the piles.

Use full-length piles where practicable. It is preferred that steel piling is not spliced. Splices may be made with the permission of the Engineer, or when shown in the Contract Documents. Make splices as shown in the Contract Documents. Use an approved welding process as provided in **DIVISION 700** to make the splices. Provide an experienced welder to make the welded splices for structural steel piling and shell piling. Correct or replace any failure in the splice at own expense.

Avoid extensions, splices or build-ups on prestressed concrete piles whenever possible. When splicing is necessary, make them as shown in the Contract Documents.

If the pile driving procedure causes crushing or spalling of the prestressed concrete piles, or deformation of the steel piles, remove and replace the damaged piles with new, longer piles. A second pile may be driven adjacent to the damaged pile, when approved by the Engineer and can be accomplished without detriment to the structure.

Do not force misaligned piles into proper position. Remove and replace piles driven out of their proper location with new, longer piles.

- If the driven pile is 35 feet or less in length, the maximum allowable variation from the vertical or battered lines shown in the Contract Documents is ¼ inch per foot of length.
- If the driven pile is greater than 35 feet in length, the maximum allowable variation from the vertical or battered lines shown in the Contract Documents is ⅛ inch per foot of length.
- The maximum allowable variation on the head of the driven pile from the position shown on the Contract Documents is 2 inches for piles used in bents, and 6 inches for foundation piles.

Re-drive all piles pushed up by the driving of adjacent piles, or by any other cause.

d. Bearing Values and Required Penetration. Drive the piling to attain, as a minimum, the specified bearing value, penetration and pile tip elevation. Stop driving the piling (regardless of the penetration) if 1½ times the specified minimum driving resistance is attained. Stop driving the piling if, in the opinion of the Engineer, the specified minimum driving resistance, penetration and pile tip elevation can not be attained without damage to the piling. If the specified minimum driving resistance is not attained with the specified number and length of piling, the Engineer may allow additional piling be driven so that the maximum load on any pile does not exceed its safe carrying capacity.

In the absence of loading tests, determine the safe bearing values of piles by the formulas in **TABLE 704-1**.

704 - PILING

TABLE 704-1: PILE FORMULAS		
Hammer	Pile Type	Formula
Gravity	Steel Steel Shell Steel Sheet	$P = \frac{3 W H}{S + 0.35} \left(\frac{W}{(W + X)} \right)$
Air/Steam (Single Acting)	All Types	$P = \frac{2 W H}{S + 0.1}$
Air/Steam (Double Acting)	All Types	$P = \frac{2 E}{S + 0.1}$
Delmag and McKierman-Terry*	All Types	$P = \frac{1.6 W H}{S + 0.1 \left(\frac{X^{**}}{W} \right)}$
Link-Belt*	All Types	$P = \frac{1.6 E}{S + 0.1 \left(\frac{X^{**}}{W} \right)}$

*diesel hammers

** For diesel hammers, the quantity X/W shall not be less than 1.

P = safe bearing power in pounds

W = weight in pounds, of striking part of hammer

H = height of fall in feet

E = energy of ram in foot-pounds per blow

S = the average penetration in inches per blow for the last 5 blows for gravity hammers and the last 20 blows for air/steam or diesel hammers

X = weight in pounds of the pile plus the weight of any cap and/or anvil used on the pile during driving

The above formulas are applicable only when:

- The hammer has a free fall;
- The penetration is reasonably quick and uniform; and
- There is no appreciable bounce after the blow.

If water jets are used in connection with the driving, determine the bearing capacity by the formulas above from the results of driving after the jets have been withdrawn, or a load test may be applied.

The energy rating used to determine if any type or brand of diesel hammer is of adequate size other than those shown in **TABLE 704-1**, is 80% of the energy rating as listed by the manufacturer.

Use an energy rating of 100% of the energy rating listed by the manufacturer for computing bearing values and to determine if an air/steam is of adequate size. If the number of blows per minute for an air/steam hammer deviates significantly from the number designated by the manufacturer, take corrective action as directed by the manufacturer.

e. Piling Restrike Procedure.

If a pile does not attain the minimum driving resistance within a few feet of the plan elevation, the pile restrike procedure may be used. Contact the Regional Geology Office for guidance before using the restrike procedure. Restrike procedures differ depending on whether a Test Pile, Test Pile (Special) or neither is called for in the Contract Documents. When a PDA is used, the restrike procedure will be as directed by the Regional Geologist.

(1) Use the following procedure when neither a Test Pile nor a Test Pile (Special) is called for in the Contract Documents, and the PDA is not available. The following procedure shall be used.

- Drive all of the piling in a group to within 2 feet of plan elevation;
- All of the piling in the pile group shall sit undisturbed for a minimum of 24 hours;
- Prior to starting the restrike procedure, warm the hammer up at a location as far away from the pile group as practical, preferably in another substructure member or pile group;
- One pile in the group is then immediately restruck with the warmed-up hammer for 30 blows or until the pile penetrates an additional 4 inches, whichever comes first. Record the penetration for every 5 blows. In the event the pile movement is less than ½ inch during the restrike, the restrike may be terminated after 20 blows.

704 - PILING

The driving resistance of the piling is computed based on the average penetration, if any, for the first 5 blows. The driving resistance of each piling is the driving resistance computed for the pile that was restruck. If the computed driving resistance is less than the design pile load, splice additional length onto each piling in the group and resume driving each piling until the required driving resistance is achieved.

(2) Use the following procedure when a Test Pile is called for in the Contract Documents, and the PDA is not available. The following procedure must be used.

- Drive the Test Pile to within 2 feet of plan elevation;
- The Test Pile shall sit undisturbed for a minimum of 24 hours;
- Prior to starting the restrike procedure, warm the hammer up at a location as far away from the Test Pile as practical, preferably in another substructure member or pile group;
- The Test Pile is then immediately restruck with the warmed-up hammer for 30 blows or until the pile penetrates an additional 4 inches, whichever comes first. Record the penetration for every 5 blows. In the event the pile movement is less than ½ inch during the restrike, the restrike may be terminated after 20 blows.

The driving resistance of the Test Pile is computed based on the average penetration, if any, for the first 5 blows. If the computed driving resistance is less than the design pile load, splice additional length and resume driving until the minimum driving resistance is achieved.

(3) When a Test Pile (Special) is called for on the plans, or a PDA is available, follow the recommendations of the Regional Geologist for the Restrike Procedure.

f. Pile Cut-Off and Pile Painting.

(1) After the piles are driven as specified, cut the piles off at the designated elevation. If capping is required, make the connection as shown in the Contract Documents.

Pile cut-off material becomes the property of KDOT, if the Engineer determines the pile cut-off material is worth salvaging. Store the salvageable material at the site selected by the Engineer. Pile cut-off material determined to not be salvageable becomes the property of the Contractor.

(2) Paint the exposed portion of steel piles, steel sheet piles, or the shells or castings of cast-in-place concrete piles. Unless otherwise noted in the Contract Documents, apply the paint in the field. Use the same kind of paint and total number of coats as specified for the structural steel on the structure. If a paint system is not specified for the structure, use a prime coat of inorganic zinc as required for the shop coat and an acrylic or polyurethane finish coat, as specified in **DIVISION 700** for the final coat. Apply the paint to the pile for a distance of 1 foot below the bottom of the channel, top of the embankment, natural ground or normal low water elevation.

g. Cast-In-Place Concrete Piles. After the steel shells are driven as specified, remove all loose material from inside the steel shell. Unless specified otherwise in the Contract Documents, use Grade 3.5 concrete to fill the steel shells. Do not place concrete in the steel shell until the driving of all steel shells within a radius of 15 feet from the pile is completed, or until all the piles for any one bent are driven. If this can not be done, discontinue all driving within the above limits until the concrete in the last pile cast is a minimum of 7 days old. Remove accumulations of water from inside the steel shells before concrete is placed. Consolidate the concrete in the upper 15 feet of the steel shell by internal vibration.

704.4 MEASUREMENT AND PAYMENT

The Engineer will measure the length of steel pile, steel sheet pile, cast-in-place concrete pile and prestressed concrete pile remaining in the structure, by the linear foot.

The Engineer will measure the length of prestressed concrete from the tip of the pile to the point that concrete is removed to provide the connection with the cap or footing. This measurement does not include the length of reinforcing steel extending beyond the pile and into the cap or footing.

The Engineer will measure the actual length of ordered and accepted test pile by the linear foot.

The Engineer will measure each cast steel pile point used.

If after driving the ordered and accepted length of pile, plan bearing is not achieved and additional pile is required, the Engineer will measure for payment each pile splice needed to lengthen the pile to achieve bearing. The Engineer will not measure for payment pile splices shown in the Contract Documents or pile splices approved for the Contractor's convenience.

704 - PILING

The Engineer will measure pre-drilled pile holes by the linear foot. The Engineer will measure pre-drilled pile holes from the elevation at the bottom of the hole to the bottom of the footing or abutment elevation shown in the Contract Documents. If the Contractor drills the pile holes to an elevation below that shown in the Contract Documents for bottom of hole, the additional drilling below the elevation shown in the Contract Documents is not measured for payment. Pre-drilled pile holes not specified, but drilled for the Contractor's convenience are not measured for payment.

The Engineer will measure pile cut-off by the linear foot. Pile cut-off is the difference between the length of pile ordered and accepted and the actual length of pile remaining in the structure. If the Contractor (for convenience or method of operation) uses a length of pile that exceeds the length of pile ordered and accepted, the excess length is not measured as pile cut-off.

The Pile Restrike procedure shall not be paid for separately, but shall be subsidiary to the bid item "Piling", "Test Pile" and "Test Pile (Special)".

Payment for the various types of "Piles" and "Test Piles", "Cast Steel Pile Points" and "Pre-Drilled Pile Holes" at the contract unit prices is full compensation for the specified work.

Payment for pile splices at 4 times the contract unit price of the type of pile spliced is full compensation for the specified work.

Payment for pile cut-off per linear foot as shown in **TABLE 704-2** is full compensation for the specified work.

Pile Type	% of Contract Unit Price Paid
Cast-in-place (Shell)	60
Pre-stressed concrete	75
Steel	75
Steel Sheet	75

The costs of all load tests ordered by the Engineer will be paid for as Extra Work as shown in **subsection 104.6**.