DESCRIPTION

Furnish and install prestressed (post-tensioned) concrete cylinder piles of the size and at the locations indicated on the contract plans and in accordance with the Special Pile Notes shown on the contract plans.

MATERIALS

A. The following details shall be as specified on the contract plans:

1. Required concrete strength at tensioning of prestress ($f'ci$).
2. Required 28 day concrete strength ($f'c$).
3. Initial jacking force for post-tensioning.
4. Type, diameter, and grade of prestressing strands.
5. Corrosion Protection.
6. Estimated length and size of piles (when a test pile item is used).
7. Ordered length and size of piles (when no test pile item is used).
8. Requirements for pile cleanout and fill.
9. Jetting requirements and restrictions.

All of the applicable provisions of the Precast Concrete Construction Manual (PCCM) shall apply with the following modifications and additions:

GENERAL

The completed pile shall consist of centrifugally precast concrete cylinder sections or conventionally precast concrete cylinder sections placed end to end and joined by prestressing strands placed in pre-formed holes within the pile walls.

Pile diameter, wall thickness, make-up and arrangement of prestressing strands and non-prestressed reinforcement shall be in accordance with the contract drawings.

Assemble the pile using section lengths of at least 8.0 ft. A shorter section may be used at the pile toe to make up the required length.

Sections may be prestressed into full-length piles either at the place of manufacture or at the project site, at the Contractor's option.

MATERIAL REQUIREMENTS

Material shall meet the requirements of the PCCM and the following:

Concrete: For conventional casting the air content shall be as specified in the PCCM. For centrifugal casting the air content shall be such that sufficient entrained air is within the hardened concrete to effectively resist freeze-thaw action as approved by the Deputy Chief Engineer for Structures Design and Construction (D.C.E.S.). Unless otherwise noted on the
contract plans, the minimum compressive strength of the concrete shall be 7500 psi at 28 days.

**Epoxy Resin Binder:** Material used to abut the joint surfaces of individual sections shall be an epoxy resin resistant to exposure and weathering, meeting the requirements of ASTM C881, Type I, Grade 3, class suitable for use at the ambient temperature at time of its application. Compressive strength of the cured epoxy at 28 days shall not be less than the minimum specified 28 day compressive strength of the concrete. An alternate material may be proposed with its use subject to approval by the D.C.E.S. Show the alternate on the shop drawings.

**Grout:** Replace section 4.6.3 of the PCCM with the requirements of duct grouting material included in this specification.

**DRAWINGS**

**Shop Drawings:** Shop drawings shall meet the requirements of the PCCM.

**FABRICATION**

Fabrication shall meet the requirements of the PCCM and the following:

1. Manufacture sections by the centrifugal casting process or by the conventional casting process.

2. When the centrifugal casting method is used provide a concrete mix that results in the most uniform possible distribution of aggregates across the wall of the pile sections. Fine and coarse aggregates shall have as nearly as possible the same specific gravity.

3. When the conventional casting method is used the following tests shall be conducted:

   **Slump Flow**
   Slump flow shall be tested on each batch of concrete according to ASTM C1611.

   **Visual Stability Index**
   The concrete should flow out to final slump diameter with no segregation. Check the edge of the concrete on the board for excessive bleed water called a mortar halo. The mix should appear uniform, with the coarse aggregate visible and evenly dispersed. Report the Visual Stability Index (VSI) as shown in the table below. Each batch of concrete shall have a VSI value of either 0 or 1. A VSI value of 2 or 3 will not be allowed.

   A VSI value of 0 or 1 is an indication that the SCC mixture is stable and is suitable for the intended use. A VSI value of 2 or 3 indicates possible segregation potential.
<table>
<thead>
<tr>
<th>VSI</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No evidence of segregation or bleeding.</td>
</tr>
<tr>
<td>1</td>
<td>No evidence of segregation and slight bleeding observed as a sheen on the concrete mass.</td>
</tr>
<tr>
<td>2</td>
<td>A slight mortar halo (&lt;3/8 inch) and/or aggregate pile in the slump flow patty and highly noticeable bleeding in the wheelbarrow or container.</td>
</tr>
<tr>
<td>3</td>
<td>Clearly segregating by evidence of a large mortar halo (&gt;3/8 inch) and/or large aggregate pile in the center of the concrete patty and a thick layer of paste on the surface of the resting concrete in the wheelbarrow or container.</td>
</tr>
</tbody>
</table>

**Column Segregation**

A column segregation test shall be made on the first batch of concrete in each day’s placement according to ASTM C1610. The maximum allowable static segregation shall be 15%.

**Acceptance of Sections:** Any section not fabricated in accordance with the contract documents, in accordance to the PCCM, or any section displaying any one of the following defects, shall not be accepted:

1. **Exposed Interior-Prestressing Hole.** Any section that has one or more prestressing holes open to the atmosphere.

2. **Honeycombing.** All honeycombed locations on a section shall be chipped until sound concrete is detected. Sound concrete is defined as that point where chipping causes fracture of the aggregates. If honeycombing of the section is encountered to such an extent that the honeycombed concrete causes the condition noted in the above paragraph 1, “Exposed Interior - Prestressing Hole" the unit shall be rejected.

3. **Cracks.** Any section that has a crack greater than ½” in depth and 0.005” in width.

**TOLERANCES**

**A. Precasting.**

All forms, reinforcing and prestressing steel, etc., shall be inspected for compliance with the tolerances listed below:

- Wall thickness: + 3/8”, -1/8”
- Length: 3/8” per 10 ft
- Tendon Hole Position: ± ¼”
Spiral Wire Spacer: ± ¾”
Spiral Reinforcing Steel: ± ¼”
Position of Handling Device: ± 6”
Straightness of Forms: 1/8” per 10 ft
                      3/8” per 40 ft

The portions of the forms which form the end surfaces of the pile sections shall be a true plane perpendicular to the axis of the sections with the following maximum allowable deviation:

For abutting surfaces: 1/8”
For head end surfaces: ½”
For point end surfaces: 1.0”

B. Tensioning.

All piles shall be checked for compliance with the tolerances listed below within 24 hours after tensioning of prestressing strands. The Inspector shall document to the D.C.E.S. any pile with dimensions out of tolerance.

Maximum Sweep in inches (Deviation from straightness measured along two longitudinal lines 90º apart on the faces of the pile while not subject to bending forces):

3/16” mm times the total length in feet divided by 20 ft.

Assembly of Pile Sections: In accordance with the requirements of the approved shop drawings or installation drawings.

Pile sections may be assembled and prestressed into full length piles either at the fabrication plant or project site (including off-site staging areas). Pile sections shall be handled such that no damage to the concrete will occur. Any section which has more than ten percent (10%) of the annular end surfaces spalled to a depth greater than 1/8” will not be accepted. Only pile sections accepted by the inspector shall be used for pile assembly.

Preparation of Sections for Assembly. Coat joining surfaces of adjacent sections with epoxy sealing material meeting the requirements of "Epoxy Resin Binder" of this specification. The Contractor may propose to the D.C.E.S. an alternate sealing material(s). Show the alternate on the shop/installation drawings for approval by the D.C.E.S.

Before the strands are tensioned so as to place the pile in compression, line up the individual sections so that the maximum deviation in the alignment of the outside surfaces of the two adjacent sections at the joint will not exceed ¼”, and the maximum deviation circumferentially in the alignment of the strand holes, at the joint, will not exceed ¼”. Prestressing strands shall run continuously, without couplings or splices, from end to end of the pile.
**Tensioning of Tendons.** Install two ½” diameter strands of the type indicated on the plans into each prestressing hole in the assembled pile. Tension each strand to meet the requirements on the plans and in the manner described on the approved shop or installation drawings. Temporarily anchor the strands until tendon holes are grouted and grout has achieved 4000 psi minimum compressive strength. At this time, the temporary strand anchors may be removed.

**Grouting of Prestressing Tendon Holes.** Each prestressing hole shall be thoroughly cleaned with water and be free of any contaminants immediately before grouting. All remaining water in the tendon holes shall be blown out with compressed oil free air. Steam shall not be used to clean the holes. Prepackaged, thixotropic material containing no metallic expansion aides that, when mixed with water at the proposed water/cementitious material ratio (w/c ≤ 0.40), meets the following requirements. Verify this minimum strength by compressive strength tests on grout samples conducted in accordance with ASTM C109 and witnessed by the Inspector or Engineer. Holes shall be completely filled with grout.

### DUCT GROUTING MATERIAL

<table>
<thead>
<tr>
<th>Test Requirement</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Set, hours</td>
<td>1½</td>
<td>12</td>
</tr>
<tr>
<td>Expansion, (%)</td>
<td>0.0</td>
<td>0.40</td>
</tr>
<tr>
<td>24 Hour Compressive Strength, psi</td>
<td>2000</td>
<td>-</td>
</tr>
<tr>
<td>7 Day Compressive Strength, psi</td>
<td>3600</td>
<td>-</td>
</tr>
<tr>
<td>28 Day Compressive Strength, psi</td>
<td>5000</td>
<td>-</td>
</tr>
<tr>
<td>Fluidity efflux timea, seconds (0.035 ft³ discharge of grout)</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>Total Chloride Content, % by weight</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td>Total Sulfate Content, % by weight</td>
<td>-</td>
<td>5.0</td>
</tr>
</tbody>
</table>

*a* Allow the grout to idle for 30 minutes; then remix it for 30 seconds. Efflux time immediately after remixing - ≤ 30 seconds.

**SHIPPING**

Shipping may be done under either of the following conditions:

1. Unassembled individual sections.
2. Assembled, full-length prestressed piles.

No section, or pile, shall be shipped without the acceptance of the inspector.

**BASIS OF ACCEPTANCE**

The Inspector's mark of acceptance shall constitute the basis of acceptance for shipment of any one individual section to the project site. If full-length piles are shipped, each individual
section which makes up the pile shall exhibit the Inspector's stamp of approval as well as the Inspector’s stamp of approval for the full-length pile. Any full-length pile which incorporates an unstamped section or an unstamped full-length pile shall be subject to rejection at the project site, with the concurrence by the D.C.E.S.

CONSTRUCTION DETAILS

At least thirty days prior to the beginning of any pile installation work, submit the installation drawings, and other data. Installation drawings and design computations shall be submitted meeting the requirements of the PCCM and the following:

1. Methods to be used for handling and transporting the piles and the number and location of pile pickup points.

2. Calculations showing that the stress in the piles due to the proposed shipping and handling methods shall not exceed $0.158 \sqrt{f'c_i} \text{ (ksi)}$ for tension stresses and $0.6 \ f'c$ for compression stresses.

3. Written procedure for the proposed method of construction. This shall include the capacity of the equipment.

4. Written procedure to be used for jetting of the piles if jetting is permitted or required on the contract plans. This shall include a description and the function of all proposed equipment.

A. Storage, and Handling. The method of storing and handling of piles shall be such as to avoid damage to the piles and as shown on the approved installation drawings.

B. Site Preparation. Do not drive piles until after the excavation is completed to the elevation required for the bottom of the footing or bottom of tremie. Remove material forced up by driving, fill depressions caused by driving and establish the correct elevation of foundation before placing footing concrete, unless otherwise shown on the plans.

C. Splices. Splicing of piles is not permitted. Full length piles shall always be used. Build-ups to a maximum of 2 feet in length are allowed unless otherwise specified on the contract plans. Submit proposed details of the build-up to the D.C.E.S. for approval.

D. Equipment for Driving Piles

1. General - Drive piles with equipment which has prior approval from the D.C.E.S. The Contractor shall submit to the D.C.E.S., Form BD-138, "Pile Driving Equipment Data," for approval. The D.C.E.S. will require 15 working days upon receipt for review. Each separate combination of pile and pile driving equipment proposed by the Contractor requires the submission of a corresponding BD-138.
The minimum rated striking energy of the hammer to be used in driving is 30,000 ft-lbs per blow. Provide the Engineer with the hammer manufacturer's specifications along with charts and graphs that are required to calibrate hammer energy.

Hammers having greater striking energy may be used upon approval by the D.C.E.S. These hammers shall produce a minimum of 20 blows/foot and a maximum of 120 blows/foot at the Ultimate Pile Resistance shown on the Contract Plans. However, if in the opinion of the D.C.E.S., satisfactory results are not obtained with the hammer furnished by the Contractor, a hammer meeting approval from the D.C.E.S. shall be furnished and used at no additional cost to the State.

Hammers must be capable of producing variable energy at a consistent rate, by mechanically fixing the stroke or adjusting the volume and pressure of the motive fluid. Reduce hammer energy and/or use additional pile cushions to prevent pile cracking during soft driving conditions. Protection against cracking of the piles shall be the Contractor's responsibility. Repair or replacement of damaged piles shall be at the Contractor's expense. When the pile is approaching the design toe elevation, the maximum allowable hammer energy specified by the D.C.E.S. shall be used to develop the final driving resistance.

2. Air/Steam Hammers - Provide sufficient boiler or compressor capacity at all times to maintain the rated speed of air/steam hammers during the full time of pile driving. Maintain the valve mechanism and other parts of a single or double-acting hammer such that the number of blows per minute for which the hammer is designated, is satisfied.

3. Diesel Hammers - Maintain the valves, pumps, ports, rings, and other hammer parts such that the following condition for which the hammer is designated is satisfied:

<table>
<thead>
<tr>
<th>Hammer Type</th>
<th>Designated Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Acting</td>
<td>Length of Stroke or Blows per Minute</td>
</tr>
<tr>
<td>Double Acting</td>
<td>Bounce Chamber Pressure</td>
</tr>
</tbody>
</table>

Provide all Diesel Hammers with an acceptable means of measuring hammer energy. When pressure gages are included as normal equipment, they shall be furnished and maintained in operable condition. Arrange easy access to the pressure gages so that readings may be conveniently taken by the Engineer.

A double acting hammer not operating at the required bounce chamber pressure shall be removed promptly from the work site. It shall be replaced by a hammer acceptable to the Engineer at no cost to the State.

4. Hydraulic Hammers – Maintain the values, pumps, ports, rings, and other hammer parts such that the hammer is in proper working order. Provide all Hydraulic Hammers with an acceptable means of measuring hammer energy. When pressure gages or electronic readouts are included as normal equipment, they shall be furnished and maintained in operable condition. Arrange easy access to the pressure gages or readouts so that
readings may be conveniently take by the Engineer. Printed readouts, if provided by the hammer control system, shall be made immediately available to the Engineer.

5. Use an approved hammer cushion block to transfer pile hammer energy to the pile. Equip each hammer with a helmet/drive head to fit the type of pile to be driven. Remove the hammer cushion from the helmet and inspect it in the presence of the Engineer when beginning pile driving at each structure or after each 100 hours of pile driving, whichever occurs first. Replace the hammer cushion if during driving of a pile, the reduction in cushion thickness exceeds 25 percent of the original thickness.

6. Use an approved pile cushion block to prevent damage to the pile. Pile Cushions shall be protected from the weather and remain dry. At a minimum frequency, replace the pile cushion block after each pile is driven. Maintain pile cushions in good condition and change when charred, splintered, or excessively compressed or as ordered by the Engineer. Replace the pile cushion if during the driving of a pile, it is either compressed more than one half the original thickness or begins to burn.

7. Pile driving leads shall be constructed in such a manner as to afford freedom of movement of the hammer. The use of either swinging or hanging leads will be permitted provided the pile or leads are properly supported during driving and the required final position and batter of pile is achieved. In the event the Engineer determines that the use of swinging or hanging leads is producing unsatisfactory results, he may require the Contractor to hold the leads in position with guys or braces to give the required support. The Contractor may, as an alternative, replace the unsatisfactory equipment with equipment having fixed leads.

Pile driving leads shall be of sufficient length so that the use of a follower will not be necessary. The driving of piles with followers will generally not be permitted and shall be done only with written permission and direction of the D.C.E.S.

When directed by the Engineer, use either approved steel or wooden spuds to penetrate consolidated material or obstructions in the upper 10 feet in order to assist in driving the piles to the required depth and resistance. Augers may be used for this purpose when written permission is obtained from the D.C.E.S.

8. If noted on the contract plans, water jets can be used to partially install piles. Piles installed with water jets shall be impact driven to secure the final penetration. Use of water jets to progress the pile simultaneously with impact driving is forbidden.

9. Vibratory hammers shall not be used in driving any pile.

E. Methods of Driving. The driving of piles shall be done with an air/steam, diesel, or hydraulic hammer.
F. Length of Piles

1. **General.** Piles will be driven at the locations shown on the contract plans and to the pile toe elevation and driving criteria established by the D.C.E.S. The location, number, lengths, and methods of driving piles may be changed as directed by the D.C.E.S. at any time during the progress of the work. Piles may be completely driven in one operation or, if directed by the D.C.E.S., may be partially driven and allowed to set from 2 to 24 hours (or as indicated on the Contract Plans) before driving is resumed.

2. **Test Piles.** When a test pile item is specified on the contract plans, test piles will be driven to determine the ordered lengths of foundation piles to be used. An order list will be furnished after satisfactory completion of all test piles in the substructure. Furnish and place in the leads piles of the ordered lengths shown on the itemized list furnished by the Engineer.

   Test piles that are driven within the structure limits may be used as foundation piles, if properly located in accordance with the plans and driven to the driving criteria established by the D.C.E.S.

G. **Allowable Variation in Pile Alignment.** Piles shall be truly vertical or accurately battered as indicated on the Contract Plans. Any pile driven its full length into the ground shall not vary from the plan location at the point of cut off by more than 3”, unless otherwise shown on the Contract Plans. In addition, piles may have a variation at their toe of not more than 1/8” per foot from the vertical or from the batter shown on the Contract Plans or permitted by the D.C.E.S.

H. **Defective Piles.** All piles forced up by any cause shall be driven again, as directed by the Engineer. Defective piles or piles damaged during driving or handling will be rejected. Corrective measures shall be submitted by the Contractor to the D.C.E.S. for approval. Approved corrective measures undertaken by the Contractor shall be at his sole expense.

Damaged piles which cannot be satisfactorily repaired or which do not meet dimensional tolerances shall be removed and replaced by the Contractor at no cost to the State.

The following shall be causes for rejection of a pile:

1. Pile location or batter is incorrect.
2. Pile damaged from any cause whatsoever.
3. Pile fails to attain the driving criteria determined by the D.C.E.S., or the driving resistance shown on the Contract Plans.
4. Pile toe elevation is not within the limits called for on the Contract Plans, or specified by the Engineer.
5. Pile is determined by the Engineer to be unserviceable for other reasons related to the furnishing and installing of the pile.
6. Pile which is driven to final toe elevation is damaged below cut off elevation.
7. Any pile broken by reason of internal defects (even if placed in the leads), or improper driving.
8. Pile which is driven so that when cut off, the butt is below the elevation fixed by the Contract Plans or established by the Engineer.

I. Cutting Off Piles. Submit for approval by the Engineer, the proposed equipment and procedures for saw cutting piles. Cut off the tops of all piles at the elevation indicated on the Contract Plans, or as established by the Engineer. The cut shall be clean and to a true plane, in accordance with the detail shown on the Contract Plans. All cut off lengths shall become the property of the Contractor.

J. Included Work. Backfill all cavities left by the pile driving operation as specified by the Engineer.

K. Pile Fill. After each cylinder pile has been driven to its final penetration and approved. Partially clean out the pile if specified on the contract plans and fill in accordance with the details shown on the plans.

L. Internal Pressure. Very soft soils or water inside the piles may produce high internal pressures. Observations shall be made during driving to determine whether or not the soil or water inside the pile shall be lowered as necessary to eliminate the possibility of building up internal pressures which might damage the pile. Do not allow water to rise high enough to completely fill the pile. Such checks are to be made as necessary during driving to prevent any undue build-up of internal plug and water within the pile. Piles damaged by such conditions shall be replaced at the sole expense of the Contractor. If airlifting bailing or venting of the drive head is found to be necessary, the Contractor shall provide means to prevent siltation of the waterway.

METHOD OF MEASUREMENT

A. General. When field conditions necessitate a change to the ordered length of test piles, the minimum additional length specified shall be 5.0 feet. Any lengths of pile beyond the ordered length that is necessary to facilitate the Contractor's operation shall be at his own expense. Pile build-ups will not be measured for payment.

B. Test Piles. The quantity of test piles to be paid for under the work specified will be the ordered number of linear meters of test pile shown on the contract plans and any additional lengths ordered placed in the leads by the Engineer.

C. Piles (when used in conjunction with test pile item). The quantity of piles to be paid for under the work specified will be the number of linear feet of piles placed in the pile driving leads, in accordance with the Engineer's order list. The pile lengths shown on the contract plans are for estimating purposes only.

D. Piles (when not used in conjunction with test pile item). The quantity of piles to be paid for under the work specified will be the ordered number of linear feet of piles shown on the contract plans and any additional lengths ordered placed in the leads by the Engineer.
BASIS OF PAYMENT

Piles. The unit price bid per linear feet for each of the respective pile items includes the cost of furnishing all labor (including the manipulation of pile driving equipment and materials), materials and equipment (excluding pile driving equipment) necessary to complete the work as prescribed in the Specifications including the following additions:

A. Structure Excavation. Work associated with the removal of any material forced up above the foundation by the driving of piles shall be included in the unit price bid for the respective pile item.

B. Defective Piles. No payment will be made for piles rejected in accordance with the requirements of CONSTRUCTION DETAILS - H. Defective Piles of this Specification.

C. Backfilling. Payment for backfilling of all cavities left by the extraction of damaged piles or from auger holes or soil deformations necessary to place piles shall be included in the unit price bid for the respective pile item.

D. Redriving Piles. The cost of driving piles that are forced up by any cause shall be included in the unit price bid for the respective pile item.

E. Ordering Piles. Any piles ordered by the Contractor prior to receipt of the Engineer's order list shall be the Contractor's responsibility and expense.

F. Water Jets, etc. The cost of furnishing and using water jets, airlifts, bail buckets, augers, followers, or spuds shall be included in the unit price bid for the respective pile item.

Furnishing equipment for driving piles will be paid for separately under its appropriate item.

Payment for Piles. Progress payments will be made for each pile properly installed in accordance with the Plans, Specifications and orders of the Engineer. Payment will be made, at the unit price bid, for 80% of the quantity properly installed, exclusive of cutting off the pile tops and cleaning out the inside of the piles for preparation of pile fill. The balance of the quantity will be paid for upon completion of the work, including cutting off the pile tops and cleaning out the inside of the piles.

Note: nn denotes serialized pay item.