

## **ITEM 16551.69nn M - PRESTRESSED CONCRETE CYLINDER TEST PILES**

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### **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. Ordered length and size of test piles.
  7. Estimated length and size of piles (when a test pile item is used).
  8. Ordered length and size of piles (when no test pile item is used).
  9. Requirements for pile cleanout and fill.
  10. Jetting requirements and restrictions.

**All of the provisions of Subsection 718-01 of the Standard Specifications shall apply with the following modifications and additions:**

#### **GENERAL.**

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

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

Assemble the pile using section lengths of at least 2.44 m. 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.**

**Concrete:** Concrete shall meet the requirements of Subsection 501-2 of the Standard Specifications with the following modifications:

1. Portland cement shall be Type 2, sulfate resistant.
3. Concrete requirements for Classes A through J shall not apply.

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4. 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.).
6. Unless otherwise noted on the contract plans, the minimum compressive strength of the concrete shall be 48 MPa at 28 days.
7. Corrosion inhibitor (calcium nitrite) shall be added to the concrete mix at the rate of 26.7 liters/m<sup>3</sup>. Calibrate the calcium nitrite discharge device by a method approved by the D.C.E.S.

**Steel:**

1. Bar reinforcement shall meet the requirements of Subsection 709-01.
2. Spiral reinforcement shall meet the requirements of Subsection 709-01.
4. Prestressing steel shall be 7-wire strands, grade 1860 meeting the requirements of ASTM A416 M. The type of strand will be low-relaxation.
6. Unless otherwise noted on the contract plans, all pile reinforcement and dowels used in pile connections and build-ups shall be epoxy coated meeting the requirements of Subsection 709-04.

**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 working drawings.

**Drawings:**

**Types.**

**2. Working Drawings**

**B. Information Required on working drawings.**

- (1) This information is not required.
- (14) Submit on the working drawings the intended procedure to be used to verify minimum tensioning strength for the concrete pile segments. This procedure will be subject to approval by the D.C.E.S.

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- (15) Submit on the working drawings the proposed cement grout mix to be used to fill the prestressing holes during tensioning. The grout mix design shall incorporate the use of a corrosion inhibitor (calcium nitrite) which shall be added to the mix at the rate of 26.7 liters/m<sup>3</sup>. Calibrate the calcium nitrite discharge device by a method approved by the D.C.E.S. The grout mix design shall not be subject to approval, but the specific type of corrosion inhibitor shall be subject to approval by the D.C.E.S.
- (16) Submit on the working drawings the number of units (lot size), to be represented by the testing procedures of the CONCRETE STRENGTH REQUIREMENTS subsection. The lot size shall be subject to approval by the D.C.E.S., who may direct a different lot size to be used than that proposed.
- (17) Submit on the working drawings the specific detailed procedures to be followed for pile assembly, including: end section preparation, tensioning sequence and procedure and method of grouting prestressing holes. These procedures will be subject to approval by the D.C.E.S.

**Concrete Forms:**

1. **General.** Metal forms shall be used and shall be well braced and stiffened to prevent deformations under pressure of the wet concrete during fabrication. They shall have smooth joints and inside surfaces accessible for adequate cleaning.

Form longitudinal holes for prestressing strands in the walls of the pile sections during casting. Form the holes so that the diameter and the minimum cover, shown on the plans, are achieved. Forms for the holes shall be held firm to avoid movement during pile casting. The spiral steel reinforcement shall be outside the strand holes and shall have at least the minimum concrete cover to the outside surface of the pile section, as that indicated on the plans. Properly plumb and align the holes so that when a full-length pile is completely assembled, at least one-half of the diameter of the hole is visible from one end of the pile to the other.

2. **Void - Producing Forms.** The requirements for Void-Producing Forms shall not apply.

**Reinforcement and Prestressing Steel:** The individual pile sections shall have a cage of non-prestressed reinforcing steel, arranged and dimensioned as shown on the plans. The reinforcing spacer shall be securely held in position during the centrifugal casting of the concrete pile segment.

The number, diameter and arrangement of the prestressing strands shall be in accordance with the details shown on the plans. The wall thickness of the pile section shall be as

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specified on the plans. The reinforcement and prestressing steel may have an alternative pattern subject to the approval by the D.C.E.S.

**Tensioning of Prestressing Strands:** These requirements shall not apply.

**Concrete Mix Design and Proportioning:** The minimum strength shall be 48 Mpa, unless otherwise specified on the contract plans..

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.

**Placing Concrete:** The following requirements shall apply:

- a. Concrete shall not be placed without the Inspector's approval.
- b. Manufacture sections by the centrifugal casting process.
- c. The concrete mixture shall be cast such that it will give the best possible distribution of the aggregate across the wall section.
- d. When the atmospheric temperature is below 5°C, the fabrication of the units shall be in accordance with the winter concreting procedures approved on the working drawings, at no additional cost to the State.

**Finishing:** All concrete surfaces shall be true and even and free from open or honeycombed areas, depressions or projections.

**Curing:** Curing compounds will not be permitted.

Under subsection 2 B. Non-Accelerated Cure, 2. Final Curing Phase: Change the words "...minimum transfer strength..." to "...minimum tensioning strength..."

**Transfer of Prestress.** This shall not apply.

**Concrete Strength Requirement:** Under subsection 2A. Transfer Strength: Change the words "...transfer strength..." to "...minimum tensioning strength..." wherever they appear. Cylinder testing shall be representative of the established lot size.

**Rejection of Sections:**

Any section not fabricated in accordance with the contract documents, or any section displaying any one of the following defects, shall be subject to rejection:

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

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3. **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 2, "Exposed Interior - Prestressing Hole" the unit shall be rejected.
  
4. **Cracks.** Any unit that has a crack greater than 13 mm in depth and 0.10 mm in width.

**Tolerances:**

**A. Precasting.**

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

|                              |                                |
|------------------------------|--------------------------------|
| Wall thickness:              | + 10 mm, -3 mm                 |
| Length:                      | 10 mm per 3 m                  |
| Tendon Hole Position:        | ± 6 mm                         |
| Spiral Wire Spacer:          | ± 18 mm                        |
| Spiral Reinforcing Steel:    | ± 6 mm                         |
| Position of Handling Device: | ± 150 mm                       |
| Straightness of Forms:       | 3 mm per 3 m<br>10 mm per 12 m |

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:  | 3 mm  |
| For head end surfaces:  | 13 mm |
| For point end surfaces: | 25 mm |

**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 mm (Deviation from straightness measured along two longitudinal lines 90° apart on the faces of the pile while not subject to bending forces):

5 mm times the total length in meters divided by 6 m.

**Assembly of Pile Sections:** In accordance with the requirements of "Drawings," Subsection 2B, Number 18, submit pile assembly procedures.

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Pile sections may be assembled and prestressed into full length piles either at the fabrication plant or project site. 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 3 mm shall be rejected. Piles shall consist only of sections which have attained the minimum specified 28 day concrete compressive strength as determined by test cylinders representative of, and cured in the same manner as, the sections.

**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 working 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 6 mm, and the maximum deviation circumferentially in the alignment of the strand holes, at the joint, will not exceed 6 mm. Prestressing strands shall run continuously, without couplings or splices, from end to end of the pile.

**Tensioning of Tendons.** Install two 12.7 mm diameter strands of the type indicated on the plans into each prestressing hole in the assembled pile. Tension each strand to the force shown on the plans and in the manner described on the approved working drawings. Temporarily anchor the strands until tendon holes are grouted and grout has achieved 28 MPa 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. Steam shall not be used to clean the holes. Use a grout mixture which has 28 MPa minimum compressive strength at 28 days. Add corrosion inhibitor (calcium nitrite) at a rate of 26.7 liters/m<sup>3</sup> to the grout mixture. 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.

**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 prior to the attainment of the minimum 28-day compressive concrete strength. Nor shall any section be shipped before seventy-two (72) hours have passed subsequent to the transfer of prestress.

### **BASIS OF ACCEPTANCE.**

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The Inspector's stamp of approval 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. Any full-length pile which incorporates an unstamped section shall be subject to rejection at the project site, with the concurrence by the D.C.E.S.

### CONSTRUCTION DETAILS

**Approvals:** At least thirty days prior to the beginning of any pile installation work, submit the following for approval by the D.C.E.S.:

1. Methods to be used for handling and transporting the piles and the number and location of pile pickup points. This shall include, but not be limited to, working drawings, and stress analysis, at least three copies of each.
2. Written procedure for the proposed method of construction. This shall include the capacity of the equipment.
3. 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.

Submit working drawings, and other data in accordance with the size and type requirements stated under subheadings: "Drawings," "Types," "2. Working Drawings," "A. Size and Type" of Subsection 718-01. Design computations may be submitted on standard 216 mm x 280 mm design computation paper.

Allow the D.C.E.S. the longest of the following time durations to examine working drawings, and design computations:

1. Ten working days
2. Two working days for each drawing of a set of working drawings
3. One working day for every four design computation sheets. Any design computation sheet written on both sides will be considered as two design computation sheets.

All time for examination will begin upon receipt of all pertinent information by the D.C.E.S.

**A. Storage, and Handling.** Piles shall not be driven until a period of 30 days has elapsed after the pile sections have been cast. The method of storing and handling of piles shall be such as to avoid damage to the piles.

**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.

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**C. Splices.** Splicing of piles is not permitted. Full length piles shall always be used. Build-ups to a maximum of one meter 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 40 kJ 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 7 blows/decimeter and a maximum of 40 blows/decimeter 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:

| <b>Hammer Type</b> | <b>Designated Condition</b>          |
|--------------------|--------------------------------------|
| Single Acting      | Length of Stroke or Blows per Minute |
| Double Acting      | Bounce Chamber Pressure              |

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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. 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.
5. 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.
6. 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 3 m 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.

7. 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.
8. Vibratory hammers shall not be used in driving any pile.

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**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 75 mm, unless otherwise shown on the Contract Plans. In addition, piles may have a variation at their toe of not more than 10 mm per meter 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.

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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 1.5 m. 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 meters 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.

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**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 meters 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 meter 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, see Subsection 101-53.