4.2 PRECAST CONCRETE DRIVEN PILES

4.2.1 Description

This work shall consist of precast reinforced or prestressed concrete piles furnished and driven in accordance with these Specifications and in conformity with the requirements shown on the Drawings or elsewhere in the Contract Documents.

The type and sizes of piling to be used shall be as indicated on the Drawings. Where precast concrete driven piles have been used for the design, the Engineer shall consider and may give approval for the use of alternative types of piling proposed by the Contractor. The Contractor in submitting an alternative type of pile shall provide design data, piling experience records and calculations supporting the pile design and any variations in the substructure.

4.2.2 Materials

4.2.2.1 Concrete

Precast concrete piles shall be constructed in accordance with the details shown on the Drawings, and of the concrete class, proportions, method of mixing and placing in accordance with the provisions of Section 5.1. All cement used shall be type 1 and concrete shall contain not less than 350 kg of cement per m$^3$.

The cross sectional dimensions of the pile shall be not less than those specified and shall not exceed them by more than 10 mm.

Any face of a pile shall not deviate by more than 6 mm from a straight edge 3 metres long laid on the face, and the centroid of any cross section of the pile shall not deviate by more than 1/1,000 of the length of the pile from the straight line connecting the centroids of the end faces of the pile.

4.2.2.2 Formwork

The formwork for square precast concrete piles shall conform to the general requirement for concrete formwork as described in Section 5.1.

The head of each square pile shall be square to the longitudinal axis. The corners of the head and the corners of the pile shaft for a distance of 300 mm from the head shall be chamfered 25 mm x 25 mm.

4.2.2.3 Prestressing Steel

All prestressing steel shall comply with the general provisions of Section 5.3. All prestressing tendons shall comply with the details shown on the Drawing as to the quality, size, position and prestressing force introduced to the pile.

4.2.2.4 Reinforcement

Reinforcement steel shall be in accordance with the provisions set out in Specifications Section 5.2 and positioned as shown on the Drawings.
4.2.3 Production of Piles

4.2.3.1 Casting

Square piles shall be cast in a horizontal position. Special care shall be taken to place the concrete so as to produce a pile free from any air pockets, honeycombing or other defect.

Concrete shall be placed continuously and shall be compacted by vibrating or by other means satisfactory to the Engineer. The forms shall be slightly overfilled, the surplus concrete screeded off, and the top surfaces finished to a uniform, even texture similar to that produced by the forms.

Piles may only be constructed in separate shorter elements with the approval of the Engineer. Joints made after casting and/or stressing shall be at least as strong as the piles themselves in every respect.

4.2.3.2 Tensioning Procedure (Prestressed Piles Only)

Tensioning shall be carried out only in the presence of the Engineer, or his representative, unless otherwise approved in writing.

As used here the word “tendon” shall be defined as any single prestressing element used to apply prestressed forces to the concrete. For pretensioning this shall be each strand or straight wire.

All tendons to be stressed in a group shall be brought to a uniform tension of approximately 500 kilograms per tendon prior to being given their full tension. After this initial stressing the group shall be stressed to a total tension as required on the Drawings by means of hydraulic jacks or other approved appliances equipped with gauges graduated to read directly to 1% of the total load applied, and calibrated to measure accurately the stress induced in the steel. This induced stress shall be measured by elongation of the tendons and checked by gauge pressure. The results obtained shall be within 5% of each other.

Means shall be provided for measuring the elongation to an accuracy of one millimetre in twenty metres of length between jacking heads. In the event of apparent discrepancies of more than five percent between stresses indicated by gauge pressure and elongation, the entire operation shall be checked carefully and the source of error determined and corrected before proceeding further.

Independent references shall be established adjacent to each anchorage to indicate any yielding or slippage that may occur between the time of initial stressing and final release of the tendons.

4.2.3.3 Curing

Curing of the concrete shall be commenced prior to the formation of surface shrinkage cracks and as the concrete has hardened sufficiently to prevent injury. Curing shall conform to the requirements of Section 5.1.

4.2.3.4 Release (Pretensioned Piles Only)

For precast pretensioned members the tendon stress shall be maintained between anchorages until the concrete has reached a compressive strength equal to the “Transfer Strength” specified on the Drawings. After strength requirements are attained, the tension in the tendons shall be gradually and simultaneously released and the tendons cut off as required in such a way as to prevent shock. It shall be the...
Contractor’s responsibility to transfer the prestress safely and to the Engineer’s satisfaction in all respects.

A recess shall be cut at the ends of piles around each tendon to allow cutting off the tendon and filling the recess with grout so that the cover to the end of the tendon is not less than 20 mm.

4.2.3.5 Finishing

Piles shall present a true, smooth, even surface free from any surface blemishes and true to the dimensions shown on the Drawings, within the tolerance limits.

4.2.3.6 Marking of Piles

After a pile has been cast, the date of casting, reference number, length and, where appropriate, the prestressing force shall be clearly inscribed on the top surface of the pile and also clearly and legibly marked on the head of the pile. In addition, each pile shall be marked at intervals of 250 mm along the top 3 metres of its length before being driven.

4.2.3.7 Handling and Storage of Piles

The method and sequence of lifting, handling, transporting and storing piles shall be such that the piles are not damaged. The lifting point of each size of pile shall be proposed by the Contractor with supporting calculations for approval of the Engineer which verifies the pile will not be damaged during lifting, handling, transporting and storage. During transport and storage, piles shall be stored on adequate supports located under the lifting points of the piles.

Concrete shall at no time be subjected to loading, including its own weight, which will induce a compressive stress in it exceeding one third of its strength. For this purpose the assessment of the strength of the concrete and of the stresses produced by the loads shall be subject to the agreement of the Engineer.

All piles within a stack shall be in groups of the same length. Packings of uniform thickness shall be provided between piles at the lifting points.

4.2.3.8 Spliced Piles

Where the Drawings do not detail any splices in piles, the Contractor may adopt spliced piles provided details of the splicing method and drawings are submitted to the Engineer for approval prior to the manufacture of the piles.

4.2.4 Driving Piles

4.2.4.1 Strength of Piles

Piles shall not be driven until the concrete has achieved the specified 28 day strength.

4.2.4.2 Leaders and Trestles

At all stages during driving and until incorporation in the superstructure, the pile shall be adequately supported and restrained by means of leaders, or other guide arrangements to maintain position and alignment and to prevent buckling. These arrangements shall be such that damage to the pile does not occur. Leaders shall be of sufficient length to make the use of followers unnecessary.
4.2.4.3 Driving Equipment

Before any piling work is commenced the Contractor shall submit to the Engineer full details of the pile driving equipment and the method he intends to use in carrying out the work.

For special types of piling, driving head mandrels, or other devices in accordance with requirements shall be provided so that piles may be driven without injury.

The driving equipment shall be of a type which assures that the energy needed to penetrate the pile to the required depth is transmitted to the pile head without damaging the pile. Efficiency factor of the hammer, i.e. the relation between the theoretical energy developed by the hammer and the energy submitted to the pile, shall be minimum 0.7.

Piles shall be driven with steam, air, diesel or gravity hammers. When diesel hammers are used, they shall be calibrated by load tests if necessary.

When gravity hammers are used for driving concrete piles, the drop of the hammer shall not exceed 1 metre and the hammer shall have a weight of not less than 80% of the weight of the pile and the driving head. The fall shall be regulated so as to prevent injury to the pile.

The minimum energy developed by other types of hammers shall be the same as specified for gravity hammers.

4.2.4.4 Driving Procedure and Redrive Checks

Each pile shall be driven continuously until the specified or approved set and/or depth has been reached, except that the Engineer may permit the suspension of driving if he is satisfied that the rate of penetration prior to the cessation of driving will be substantially re-established on its resumption or if he is satisfied that the suspension of driving is beyond the control of the Contractor. A follower (long dolly) shall not be used.

The Contractor shall inform the Engineer without delay if an unexpected change in driving characteristics is noted. A detailed record of the driving resistance over the full length of the nearest available pile shall be taken if required.

At the start of work and in a new area or section, sets shall be taken at intervals during the last 3 metres of the driving to establish the behaviour of the piles.

The Contractor shall give adequate notice and provide all facilities to enable the Engineer to check driving resistances. A set shall be taken only in the presence of the Engineer unless otherwise approved.

Redrive checks, if required, shall be carried out to an approved procedure.

4.2.4.5 Final Set

The final set of each pile shall be recorded either as the penetration in millimetres per 10 blows or as the number of blows required to produce a penetration of 250 mm.

When a final set is being measured, the following requirements shall be met:

a) The exposed part of the pile shall be in good condition without damage or distortion.
b) The dolly and packing, if any, shall be in sound condition.
c) The hammer blow shall be in line with the pile axis and the impact surfaces shall be
flat and at right angles to the pile and hammer axis.
d) The hammer shall be in good condition and operating correctly.
e) The temporary compression of the pile shall be recorded if required.

4.2.4.6 Driving Sequence and Risen Piles

Piles shall be driven in an approved sequence to minimise the detrimental effects of
heave and lateral displacement of the ground.

When required, levels and measurements shall be taken to determine the movement of
either the ground or of any pile which results from the driving process.

When a pile has risen as a result of adjacent piles being driven, the Contractor shall
submit to the Engineer his proposals for correcting this and the avoidance of it in
subsequent work.

4.2.4.7 Jetting

Water jetting shall not be allowed. Continuous vibratory percussive methods shall be
used to drive a pile to both its design depth as well as the required set where the upper
strata affords high resistance to driving.

4.2.4.8 Length of Piles

The lengths of the piles shown on the Drawings are based on information which has
been obtained from a site investigation prior to the driving of test piles.

Before pile lengths are finally settled, the Contractor shall construct to the lengths
shown on the Drawings such pilot piles as may be found necessary and these piles
shall be driven in the positions specified by the Engineer who shall be notified in
advance of the driving. The Contractor shall furnish the Engineer daily with a detailed
record of the pilot piles for the full depth of driving. After attaining the approved set,
driving shall be continued until the Engineer directs that it shall cease. Driving of pilot
piles beyond the point at which the approved set is obtained shall be called for to
demonstrate that driving resistance continues to increase. The Contractor shall then
provide the remainder of the piles. In determining the lengths of piles the Contractor
shall base his order list on the lengths assumed to remain in the completed structure.
The Contractor at his own expense can increase the lengths to provide for fresh
heading and for such lengths as may be necessary to suit his method of operation.

Reference is made to Section 4.4 with regard to load tests on selected pilot piles.

4.2.4.9 Repair or Damaged Pile Heads

When repairing the head of a pile, the head shall be cut off square at sound concrete,
and all loose particles shall be removed by wire brushing, followed by washing with
water. If the pile is to be subjected to further driving, the head shall be replaced with
concrete of an approved grade.

If the driving of a pile has been accepted but sound concrete of the pile is below the
cut-off level, the pile shall be made good to the cut-off level with concrete of a grade
not inferior to that of the concrete of the pile.

Repaired piles shall not be driven until the added concrete has reached the specified
characteristic strength of the concrete of the pile.
4.2.4.10 Cut off and Extension

Prestressed concrete piles shall be cut off at such elevation that they shall extend into the cap or footing as indicated on the Drawings. In the case of hollow core piles starter bars shall be cast into the core at the top of the piles and extended into the cap or footing, all as shown on the Drawings. Extensions to prestressed concrete piles shall generally not be permitted, unless a provision for lengthening prestressed piles was incorporated at the time of manufacture. Any method for lengthening shall be such that joints are capable of taking safely the stresses during driving and under load.

4.2.4.11 Damage to Adjacent Structures and Services

The Contractor will take all necessary precautions to avoid damage to any adjacent structures and services. If during the execution of the work damage is, or is likely to be, caused to any adjacent structures or services, the Contractor shall submit to the Engineer his proposals for repair or avoidance of such damage.

4.2.4.12 Records

The Contractor shall keep records as indicated below of the installation of each pile and shall submit two signed copies of these records to the Engineer not later than noon of the next working day after the pile is installed. The signed records shall form a record of the work.

The following data are required:

a) Pile location
b) Pile reference number
c) Pile type
d) Nominal cross-sectional dimensions or diameter
e) Length of preformed pile
f) Date and time of driving or redriving
g) Ground level at commencement of installation of pile
h) Working level
i) Pile toe level
j) Type, weight, drop and mechanical condition of hammer and equivalent information for other equipment
k) Number and type of packing used and type and condition of dolly used during driving the pile
l) Set of pile in mm per 10 blows or number of blows per 250 mm of penetration
m) If required, the sets taken at intervals during the last 3 metres of driving
n) If required, temporary compression of ground and pile from time of a marked increase in driving resistance until pile reaches its final level
o) All information regarding obstructions delays and other interruptions to the sequence of work

4.2.5 Tolerances

4.2.5.1 Setting Out

Setting out shall be carried out from the main grid lines of the proposed structure. Before installation of the pile, the pile position shall be agreed with the Engineer and marked with suitable identifiable pins or markers.

4.2.5.2 Position
For a pile cut off at or above ground level the maximum permitted deviation of the pile centre from the centre point shown on the setting out drawing shall be 75 mm in any direction. An additional tolerance for a pile head cut off below ground level shall be permitted in accordance with Sections 4.2.5.3 and 4.2.5.4.

4.2.5.3 Verticality

The maximum permitted deviation of the finished pile from the vertical shall be 1 in 50.

4.2.5.4 Rake

The piling rig shall be set and maintained to attain the required rake. The maximum permitted deviation of the finished pile from the specified rake shall be 1 in 25.

4.2.6 Defective Piles

The procedure of driving the piles shall not subject them to excessive and undue abuse producing crushing and spalling of the concrete or deformation of the steel. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, shall not be permitted. Any pile damaged by reason of internal defects, or by improper driving or driven out of its proper location or driven below the elevation fixed by the plans or by the Engineer, shall be corrected at the Contractor’s expense by one of the following methods approved by the Engineer for the pile in question:

1) The pile shall be withdrawn and replaced by a new and if necessary, a longer pile.

2) A second pile shall be driven adjacent to the defective or low pile.

3) The pile shall be spliced or built up as otherwise provided herein or a sufficient portion of the footing extended to properly embed the pile.

4.2.7 Measurement

The unit of measurement shall be the linear metre of pile furnished, driven and accepted in the structure. The pay lengths of the satisfactorily driven piles shall be measured from the toe to the cut off.

Cut off lengths shall not be measured for payment.

Reinforcement steel shall be measured in accordance with Specifications Section 5.2.4.

4.2.8 Payment

Precast concrete driven piles shall be paid for at the Contract unit rate per linear metre. The rate shall constitute full compensation for all materials but excluding reinforcement, which shall be paid for separately. The rate shall also include all shoes, equipment, hardware, formwork etc., driving, cutting off, lengthening and splicing, welding and coupling and all related tools, rigs, cranes, boilers, hammers, leaders, labour and other incidental equipment and work.

Payment for precast concrete driven pilot piles (see Section 4.4.1.2(e) for definition of pilot pile), completed and accepted, shall be made at the Contract unit price per linear metre for providing piles of the size specified. When pilot piles are incorporated in the foundation as working piles, no additional payment shall be made for the piles.

Payment for reinforcement steel shall be at the Contractor’s rates per tonne for mild steel and high yield deformed steel bars.
No payment shall be made for unauthorised, defective, unsound or unsatisfactorily driven piles or for any costs incurred by the Contractor for such piles.

Payment for testing of piles shall be made separately, as detailed in Section 4.4.

Pay items shall be:

<table>
<thead>
<tr>
<th>Pay Item Code</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/2/1</td>
<td>Driven Precast Piles</td>
<td>Linear Metre</td>
</tr>
<tr>
<td></td>
<td>(Dimensions as indicated on the Drawings and stated in the Bill of Quantities)</td>
<td></td>
</tr>
<tr>
<td>4/2/2</td>
<td>Driven Precast Pilot Piles</td>
<td>Linear Metre</td>
</tr>
<tr>
<td></td>
<td>(Dimensions as indicated on the Drawings and stated in the Bill of Quantities)</td>
<td></td>
</tr>
<tr>
<td>4/2/3</td>
<td>Mild Steel Reinforcing Bars</td>
<td>Tonne</td>
</tr>
<tr>
<td>4/2/4</td>
<td>High Yield Deformed Steel Reinforcing Bars</td>
<td>Tonne</td>
</tr>
</tbody>
</table>