4.1 BORED CAST IN PLACE PILES

4.1.1 Description

This work comprises the construction of bored cast in place piles for bridges, including the provision of all materials and structures in accordance with these Specifications and in conformity with the requirements of the Drawings or other parts of the Contract Documents.

Piles through water and soft upper soil layers shall be provided with a permanent steel casing if shown on the Drawings.

The pile boring shall be carried out using a temporary steel casing bored to the pile toe or to a level approved by the Engineer. The temporary casing shall be withdrawn.

Under certain circumstances the Contractor may be permitted to bore all or part of the pile without casing under water or use drilling fluid to stabilise the borehole as referred to in Section 4.1.2.4.

The piles shall be concreted and reinforced to resist pile loads and horizontal forces on the pile caps according to the Drawings and these Specifications.

4.1.2 Materials

4.1.2.1 Steel Casing

This part of the Specifications only deals with the permanent steel casing. For steel casing used during boring of the pile see Section 4.1.3, Construction Methods.

When permanent steel casing is shown on the Drawings, the steel shall conform to the AASHTO Standard Specification M 183-79 (ASTM A36) or equivalent.

The minimum thickness of the permanent steel casing shall be 10 mm. The minimum length shall be from 100 mm above the bottom of the pile cap to 5 metre under the riverbed or into firm strata. If the permanent casing is used in the boring operation or if the handling and transport require a greater thickness to avoid deformation or buckling, the increase in thickness shall be provided by the Contractor at his own expense.

The steel casing shall be furnished in appropriate lengths and the joints shall be approved by the Engineer.

The casing shall be handled and stored in a manner that shall prevent buckling and other deformation as well as accumulation of dirt, oil and paint. When placed in the work it shall be free from dirt, oil, grease, paint, millscale and loose or thick rust.

The outside surface of the permanent casing of piles to river piers, for the depth indicated on the Drawings from the underside of the pile cap shall receive two coats of anti-corrosion tar type paint. The paint shall be approved by the Engineer and its application shall follow the manufacturer's instructions.

4.1.2.2 Concrete

The concrete shall conform to Section 5.1 of these Specifications. Concrete class 20 with type 1 cement shall be used.

Concrete placed under water or drilling mud by tremie shall have a cement content of not less than 350 kg/m³.
The density and consistency of the concrete shall conform to the tremie casting method and the maintenance of sufficient workability (slump) of all the concrete during the casting and casing handling period, including reasonably calculated delays, shall be secured by a design mix, (including the necessary retarders and plasticisers), tested by trial mixes prior to the pile construction.

All relevant concrete properties such as slump, time of setting, temperature and strength shall be measured on the trial mixes.

4.1.2.3 Reinforcement

The reinforcement shall conform to Section 5.2 of these Specifications.

4.1.2.4 Drilling Fluid

The following clauses shall be complied with if bentonite mud is used to stabilise the boreholes:

A) Supply

The Contractor shall obtain a certificate from the manufacturer of the bentonite powder, showing the properties of the consignment delivered to the site. This certificate shall be made available to the Engineer on request. The properties to be given by the manufacturer are the apparent viscosity range (in centipoises) and the gel strength range for solids in water.

Any other material proposed by the Contractor for the drilling fluid shall be approved by the Engineer.

B) Mixing

Bentonite and any other material shall be mixed thoroughly with clean water to make a suspension which shall maintain the stability of the pile excavation for the period necessary to place concrete and complete construction.

Where saline or chemically contaminated groundwater occurs, special precautions shall be taken to modify the bentonite in fresh water so as to render it suitable in all respects for the construction of piles.

C) Tests

The frequency of testing drilling fluid and the method and procedure of sampling shall be proposed by the Contractor and approved by the Engineer prior to the commencement of the work. The frequency may subsequently be varied as required depending on the consistency of the results obtained. The control tests shall cover the determination of density, viscosity, gel strength and pH values.

The Contractor shall supply all equipment and experienced operators required to carry out tests on the drilling mud. No additional payment shall be made for these tests which shall be considered as an essential part of the drilling operations.
4.1.3 Construction Methods

4.1.3.1 General

The Contractor shall demonstrate to the satisfaction of the Engineer that his proposed construction methods for the piles do not result in the pile shafts being weakened by contamination of the concrete, by sectional reduction, by washing out of cement, by breaking during pulling of temporary casings or in any other way, including the construction of neighbouring piles.

A) Assumed Procedure

The following construction procedure has been assumed in the tender design. The final construction procedure shall be as approved by the Engineer prior to commencing piling operations.

1. Place permanent steel casing, if required, in position and embed casing toe into river bed or firm strata. If no permanent steel casing is specified a sufficient length of temporary steel casing shall be used to stabilise the upper part of the borehole.

2. Bore and excavate inside the steel casing down to casing toe level, or to a level approved, and continue excavation to final pile tip level using either temporary casing under water, or using drilling mud. The fluid level inside casings shall at all times be at least 2 metres higher than outside the casings.

3. Carefully clean up all mud or sedimentation from the bottom of borehole.

4. Place reinforcement cage, inspection pipes etc.

5. Concrete continuously under water, or drilling fluid, by use of the tremie method.

6. Withdraw the temporary boring casing concurrently with concreting to the instructed level.

7. After hardening, break out the top section of the concrete pile to reach sound concrete.

B) Approval of Construction Method

In the tender, the Contractor shall describe the construction method he proposes, including name of proposed Sub-contractor (if any), information on boring equipment, materials, methods of work and control of quality. The Contractor shall submit references from similar jobs carried out by him and/or his proposed Sub-contractor.

During contract negotiations, the Contractor shall submit all requested supplementary detailed information in writing.

After the Contract has been awarded, the Contractor shall prepare a detailed programme and establish a procedure for the pile construction. The detailed programme shall contain all required information on materials, equipment, methods of work etc. and be approved in writing by the Engineer. Such approval shall not, however, relieve the Contractor of his responsibilities for pile construction.

The import of any boring equipment or materials by the Contractor, before he has received the Engineer’s approval of proposed construction methods, shall be at the Contractor’s risk.
4.1.3.2 Setting Out Piles

The Contractor shall check the casing position for each pile during and immediately after placing the casing, and agree it with the Engineer.

4.1.3.3 Diameter of Piles

The diameter of a pile shall be not less than the specified diameter.

4.1.3.4 Tolerances

The centre of the completed pile at the cut off level shall not deviate more than 100 mm from the theoretically correct position shown on the Drawings. The inclination of the pile shall not deviate more than 1:100 from vertical. The Contractor shall provide suitable equipment, such as an inverted pendulum, to check the verticality of the boreholes at intervals during drilling and prior to concreting.

4.1.3.5 Boring

A) Methods

Method of excavation shall be proposed by the Contractor and approved by the Engineer. Water or air jetting for boring of the piles shall not be allowed.

B) Boring Near Recently Cast Piles

Piles shall not be bored so close to other piles which have recently been cast and which contain workable or unset concrete so that a flow of concrete could be induced from or damage caused to any of the piles. Boring and excavation for a pile shall not be commenced until 24 hours after completion of any pile within a radius of 6 metres, centre to centre.

C) Temporary Casings

Temporary casing of approved quality or an approved alternative method shall be used to maintain the stability of pile excavations, which might otherwise collapse.

Temporary casings shall be free from significant distortion. They shall be of uniform cross-section throughout each continuous length. During concreting they shall be free from internal projections and encrusted concrete which might prevent the proper formation of piles.

D) Stability of Pile Excavation Using Drilling Fluid

Where a borehole is formed without casing under water or using drilling fluid for maintaining the stability of a boring, the level of the water or fluid in the excavation shall be maintained so that the water or fluid pressure always exceeds the pressure exerted by the soils and external ground water. The water or fluid level shall be maintained at a level not less than 2 metres above the level of the river water level or any artesian pressure level.

In the event of a rapid loss of water or bentonite suspension from the pile excavation, the excavation shall be backfilled without delay and the instructions of the Engineer shall be obtained before excavation at that location is resumed.

E) Disposal of Excavated Material
No excavated material shall be dumped into the river or any connecting waterway without the written approval of the Engineer. Excavated material shall be removed from site and dumped either beyond areas affected by dredging, or taken to the Contractors approved dumping areas on land. The Contractor shall be fully responsible for costs involved in removing the excavated material to spoil.

F) Pumping from Boreholes

Pumping from a borehole shall not be permitted unless a casing has been placed into a stable stratum which prevents the flow of water from other strata in significant quantities into the boring, or unless it can be shown that pumping will not have a detrimental effect on the surrounding soil or property.

G) Obstructions

Where boulders or other obstructions render it impossible to bore the pile, excavation operations inside pile casing as directed by the Engineer shall be carried out to remove obstructions and the Contractor shall be reimbursed for such operations only when the largest dimension of the obstruction exceeds 200 mm and the obstruction is found more than 2 metres below river bed.

H) Unexpected Ground Conditions

The Contractor shall report immediately to the Engineer any circumstances which indicate that in the Contractor's opinion the ground conditions differ from those expected by him from his interpretation of the site investigation reports.

I) Boring Records

During the boring of the pile, the Contractor shall compile a 'boring log' indicating depths and types of the various soil layers encountered. Disturbed samples shall be submitted to the Engineer as requested.

The Contractor shall allow for carrying out sampling and tests to check soil strengths as required by the Engineer.

J) Final Pile Toe Level

The final pile toe level shall be as indicated on the Drawing or as instructed by the Engineer after due consideration of the Contractor's proposals, boring logs and test results.

The final toe level of other piles may subsequently be altered according to the results of the test loadings detailed in Section 4.4.

K) Inspection and Cleaning Bottom of Excavation

The time between final excavation and bottom cleaning and the start of concreting shall be kept as short as possible and shall not exceed 6 hours. To achieve this, the final 2 metres of excavation shall not start until all preparations for cleaning, reinforcing and concreting are finished. In case of unexpected delay the Contractor shall dump sand or gravel in the bore to 2 metres above toe level.

On completion of the drilling an interval is required, to allow the fine materials to settle (15 minutes unless otherwise approved by the Engineer). Thereafter the bottom of the excavation shall be carefully cleaned of mud, sedimentation and other soft material by an approved method.
The Contractor shall show, to the satisfaction of the Engineer, that the bottom of the excavation is clean. Sedimentation tests shall be carried out by the Contractor in the presence of the Engineer.

If boring without casing, the diameter of the boring hole for a representative number of piles shall be measured by calliper prior to the placing of concrete. The verticality of boreholes will be checked as directed by the Engineer. These measurements shall be done by the Contractor using approved equipment and no reimbursement shall be made.

4.1.3.6 Placing Reinforcement

The reinforcement shall be placed as indicated on the Drawings. Reinforcement in the form of a cage shall be assembled with additional support, such as spreader forks and lacings, necessary to form a rigid cage. Hoops, links or helical reinforcement shall fit closely around the main longitudinal bars and be bound to them by approved wire, the ends of which shall be turned into the interior of the pile or pour. Reinforcement shall be placed and maintained in position.

The cover to all reinforcement shall be not less than 75 mm.

Joints in longitudinal steel bars shall be permitted unless otherwise specified. Joints in reinforcement shall be such that the full strength of the bar is effective across the joint and shall be made so that there is no relative displacement of the reinforcement during the construction of the pile.

Joints in longitudinal bars in piles with tension (for instance for test loading) shall be carried out by welding unless another method has been approved by the Engineer.

If the final pile toe level instructed by the Engineer is deeper than that indicated on the Drawings, the section of the pile deeper than the toe level indicated on the Drawings is not required to be reinforced, unless otherwise instructed by the Engineer.

4.1.3.7 Placing Concrete

A) Approval

No concreting shall take place before the bottom of the excavation has been cleaned, the borehole inspected and approval obtained in writing from the Engineer.

The method for placing concrete requires to be approved and conform with the following:

- The method of placing and the workability of the concrete shall be such that a continuous monolithic concrete shaft of the full cross section is formed.

- The concrete shall be placed continuously, and without such interruption as would allow the previously placed batch to have hardened. In this respect the Contractor shall submit details of his contingency plans, standby plant etc. to be utilised in the event of an equipment failure.

- The use of pumped concrete and the methods in its use shall be approved.

- The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in a casing. No spoil, liquid or other foreign matter shall be allowed to contaminate the concrete.

B) Workability of Concrete
Slump measured at the time of discharge into the pile boring shall be in accordance with Table 4.1-1.

Table 4.1-1

<table>
<thead>
<tr>
<th>Piling Mix Workability</th>
<th>Slump</th>
<th>Typical Conditions of Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum (mm)</td>
<td>Range (mm)</td>
</tr>
<tr>
<td>A</td>
<td>75</td>
<td>75 - 150                                   Placed into water-free unlined or permanently lined bore of 600 mm diameter or over, or where casting level lies below temporary casing: reinforcement widely spaced, leaving ample room for free movement of concrete between bars.</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td>100 - 200                                  Where reinforcement is not spaced widely; where cut-off level of concrete is within temporary casing; where pile bore is water-free and the diameter is less than 600 mm.</td>
</tr>
<tr>
<td>C</td>
<td>150</td>
<td>150 or more                                Where concrete is to be placed by tremie under water or drilling mud or by pumping.</td>
</tr>
</tbody>
</table>

C) Placing Concrete Under Water or Drilling Fluid

Concrete to be placed under water or drilling fluid shall be placed by tremie and shall not be discharged freely into the water or drilling fluid.

Before placing concrete, the Contractor shall ensure that there is no accumulation of silt, other material, or heavily contaminated bentonite suspension at the base of the boring, which could impair the free flow of concrete from the pipe of the tremie. A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.25, the placing of concrete shall not proceed. In this event the Contractor shall modify the mud quality.

The concrete shall be a rich coherent mix of high workability in accordance with Section 4.1.2.2 and shall be placed in such a manner that segregation does not occur.

During and after concreting, care shall be taken to avoid damage to the concrete from pumping and dewatering operations.

The hopper and pipe of the tremie shall be clean and watertight throughout. The pipe shall extend to the base of the boring and a sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the pipe of the tremie and the water or drilling fluid. The pipe shall at all times penetrate the concrete, which has previously been placed and shall not be withdrawn from the concrete until completion of concreting. The bottom of the tremie pipe shall be kept at least 1.5 metres under the surface of concrete once that amount of concrete has been placed. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water or drilling fluid. The internal diameter of the pipe of the tremie shall be not less than 150 mm for concrete
made with 20 mm aggregate and not less than 200 mm for concrete made with 40 mm aggregate. It shall be so designed that external projections are minimised, allowing the tremie to pass through reinforcing cages without causing damage. The internal face of the pipe of the tremie shall be free from projections.

The Contractor shall maintain a continuous record of the volume of concrete used and the level of the concrete in the pile. Any deviations from the theoretical, or expected, volume/level relationship shall be immediately reported to the Engineer.

4.1.3.8 Extraction of Temporary Casing

A) Workability of Concrete

Temporary casings shall be extracted while the concrete within them remains sufficiently workable to ensure that the concrete is not lifted.

B) Concrete Level

When the casing is being extracted a sufficient quantity of concrete shall be maintained within it to ensure that pressure from external water, drilling fluid or soil is exceeded and that the pile is neither reduced in section nor contaminated. The toe of the temporary casing shall be kept a minimum of 2 metres under the outlet of the tremie.

No concrete shall be placed in the boring once the bottom of the casing has been uplifted above the top of the concrete; it shall be placed continuously as the casing is extracted until the desired head of concrete is obtained.

Adequate precautions shall be taken in all cases where excess heads of water or drilling fluid could be caused as the casing is withdrawn because of the displacement of water or fluid by the concrete as it flows into its final position against the walls of the shaft.

The pile shall be concreted with a certain overheight to allow for chiselling off the top concrete down to sound hard concrete.

The pile top shall after clean cutting be embedded 100 mm in the foundation.

C) Vibrating Extractors

The use of vibrating casing extractors shall be permitted.

D) Reinforcement Cage

During concreting and pulling the casing, the reinforcement cage shall be secured against uplift and the top shall be kept under close inspection.

E) Supervision

The execution of the pile concreting shall be supervised by a qualified person of the Contractor’s staff, who will keep records on the relation between quantity of concrete used, level of concrete and withdrawal of casing.

4.1.3.9 Temporary Support
The Contractor shall ensure that free standing piles are temporarily braced or stayed immediately after driving to prevent loosening of the piles in the ground and to ensure that no damage resulting from oscillation, vibration or movement of any free-standing pile length can occur.

4.1.3.10 Records

The Contractor shall keep records as indicated below for 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 was 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) Date and time of boring
f) Date and time of concreting
g) River bed level at commencement of installation of pile
h) Working level
i) Pile toe level
j) River water levels
k) Pile head level
l) Length of temporary casing
m) Length of permanent casing
n) Soils samples taken and in situ tests carried out
o) Standing water level
p) Length and details of reinforcement
q) Concrete mix
r) Volume of concrete supplied to pile and corresponding levels of concrete and casings
s) All information regarding obstructions, delays and other interruptions to the sequence of work.

4.1.3.11 Measures in Case of Rejected Piles

If any pile is found unsatisfactory in the opinion of the Engineer for utilisation in the structure, it shall be cut off below the pile cap if so ordered by the Engineer.

The pile shall be replaced as directed by the Engineer. All extra expenses shall be borne by the Contractor and payment shall be made on the basis that no replacement pile had to be provided for the unsatisfactory pile.

When the safe bearing value of any pile is found by test to be less than the design load, longer piles or additional piles shall be installed as ordered in writing by the Engineer.
4.1.4 Measurement

The unit of measurement for bored cast in place piling shall be the linear metre of pile constructed and accepted in the structure. The payable lengths of the satisfactory bored piles shall be measured from the toe level to cut off 100 mm above the bottom level of pile cap. Pile permanent steel casing shall be measured separately in linear metres of the installed and accepted length of casing. Reinforcement steel shall be measured in accordance with Specifications Section 5.2.4.

4.1.5 Payment

Bored piles shall be paid for at the Contract unit price per linear metre. The rate shall constitute full compensation for all materials including temporary casings and concrete, but excluding reinforcement steel and Permanent Steel Casing, which items will be paid for separately. The rate shall also include boring equipment, standard penetration testing, split spoon sampling, boring, excavation, concreting, inspection and control, cutting off, welding, coupling and all related tools, rigs, cranes, jets, frames, leads, labour, and other incidental equipment and work necessary to complete the work.

Payment for bored cast in place 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.

Payment for Pile Permanent Steel Casing shall be at the Contract unit price per linear metre. The rate shall constitute full compensation for all materials, labour and plant necessary for providing and installing the casing, including all jointing, testing and coatings.

No payment shall be made for unauthorised, defective, unsound or unsatisfactorily 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:

4/1/1 Bored Cast in Place Piles (Diameter as indicated on the Drawings and stated in the Bill of Quantities) Linear Metre
4/1/2 Bored Cast in Place Pilot Piles (Diameter as indicated on the Drawings and stated in the Bill of Quantities) Linear Metre
4/1/3 Mild Steel Reinforcing Bars Tonne
4/1/4 High Yield Deformed Steel Reinforcing Bars Tonne
4/1/5 Permanent Steel Casing Linear Metre