

SPECIFICATION FOR CONTIGUOUS BORED PILING

1.0 GENERAL

1.1 Works in accordance with Specifications

Piling shall conform in all respects with the principles contained in BS 8004.

Unless otherwise stated, concrete, reinforcement and formwork shall be in accordance with the requirements in Specification on Concrete for Structures.

In the event that the provisions of other specification clauses cause ambiguity or conflict with the requirement of this Specification clauses, the latter shall take precedence unless otherwise approved by the Engineer.

1.2 Setting Out

The Contractor shall be required to employ an approved Licensed Surveyor who will set up the positions of the piles as shown in the pile layout plans of the detailed design. The Contractor will be responsible for the accuracy of location and positioning of each pile. Any errors in setting out and any consequential loss to the Employer will be made good by the Contractor to the satisfaction of the Engineer.

The Contractor shall preserve the pegs set out by the Surveyor. Should any peg be displaced or lost it must be replaced by a Licensed Surveyor to the approval of the Engineer. Upon completion of all piling works, the Contractor shall produce as-built Drawings showing the positions of all piles as installed. The positions of piles shall be verified by a Licensed Surveyor.

1.3 Tolerances

- (a) Position
The pile heads shall be positioned as shown on the Drawings within a maximum deviation of 75mm in either direction from its design position.
- (b) Verticality
For bored cast-in-situ piles, the maximum permitted deviation of the finished pile from the vertical at any level is 1 in 150. The contractor shall demonstrate to the satisfaction of Engineer the pile verticality is within the allowable tolerance.
- (c) Correction
Should piles be installed outside these tolerances affecting the design and appearance of the structure, the Contractor shall propose and carry out immediate remedial measure to the approval of the Engineer.
- (d) A 75mm gap shall be allowed between two adjacent piles for the installation of ground anchor. (Only applicable if ground anchors are used to support contiguous bored pile wall.)

1.4 Person in Charge

The piling work is to be carried out by full time operators and supervisory staff who must be experienced in the installation of the proposed type of piles.

The Contractor shall submit to the Engineer for approval, written evidence to show that the persons who will be engaged in the works have had such experience.

1.5 Piling Equipment and Accessories

The equipment and accessories must be capable of safely, speedily and efficiently installing piles to the design requirements at the project site.

Sufficient units of equipment and accessories must be provided to keep to the agreed construction schedule.

1.6 Sequence of Installation of Working Piles

The Engineer reserves the absolute right and the Contractor shall recognise such right to direct the installation of working piles in any sequence the Engineer deems necessary for the satisfactory completion of the works.

1.7 Forcible Correction Not Permitted

Where piles have not been positioned within the specified limits no method of forcible correction will be permitted.

1.8 Rejected Piles

Any piling work rejected by the Engineer not truly constructed and installed in accordance with this Specification shall be replaced or rectified by the Contractor to the approval of the Engineer and this include reinstallation of piles, and the design and construction of a modified foundation and also constructing of additional compensation piles.

1.9 Records

A record of all piles installed shall be kept by the Contractor and a copy of the record of the work done each day shall be given to the Engineer within 24 hours. The form of record shall first be approved by the Engineer before piling works commence. Any comment by the Engineer shall be incorporated into the record form.

All unexpected boring or installation conditions shall be noted in the records.

Two (2) bound sets of collated and certified (by the Contractor's P.E.) piling records of all piles shall be submitted by the Contractor to the Engineer after the completion of the piling works.

2.0 BORED CAST IN-PLACE PILES

2.1 General

The Contractor shall carry out the works in accordance with a method statement which has been approved by the Engineer. This method statement shall include inter alia length of temporary casing, details of the constituent materials of any drilling fluid used for stabilisation, the method of inspection, details of the concrete design mix, concreting method, the minimum time between the completion of one pile and the commencement of the next, and the pattern of construction.

Unless otherwise described in the Specifications, reinforcement and concrete shall comply with the requirements in Specification on Concrete for Structures. The Contractor shall ensure that damage does not occur to completed piles through his method of working. The Contractor shall

submit to the Engineer a pile installation programme. The proposed sequence and timing of pile installation shall be such that the installation works shall not cause any damage to adjacent piles. Piling works shall not commence until approval of the Engineer has been obtained. No bored pile excavation shall commence within 8m of any concreted pile which has not attained the age of 24 hours.

2.2 Tolerances

Tolerances shall be in accordance with the requirements in Clause 1.3 herein.

2.3 Concrete

(a) Trial Mix

The Contractor shall arrange to have a trial mix in the presence of the Engineer prior to the commencement of field work. The trial mix shall be carried out in accordance to the design mix submitted to the Engineer.

(b) Concrete for Piles

Unless otherwise stated, concrete used shall comply with Specification on Concrete for Structures and as approved by the Engineer. The grade of concrete shall be 30 (characteristic strength of 30 N/mm² at 28 days) with minimum cement content of 400kg per cubic meter of concrete. Concrete admixture shall only be used with the permission of the Engineer, and shall be used strictly in accordance with Specification on Concrete for Structures.

The Engineer may permit the use of ready mixed concrete provided complete details of the mix proportions and workability have been submitted to him for prior approval. Such permission shall only be given for as long as the Engineer is satisfied that the concrete complies with Specification on Concrete for Structures and the recommendations of M.S. 523. The Contractor shall ensure that the Engineer shall have access to the supplier's mixing plant at all times for inspection and checks on quality of concrete supplied. Each load shall be accompanied by a delivery note stamped with the time of mixing and stating the consignee and quantities of each material in the mix including water and additives.

(c) Concrete Testing

Close control of the mixing of the concrete shall be exercised and cube strength tests shall be carried out in accordance with M.S. 26. Unless the Engineer otherwise directs, a set of at least three 6" cubes shall be taken for every 10 cubic metres or every group of 10 batches of concrete used for the piling works. For the latter, the samples shall be taken from one single batch randomly selected from the group of batches. One cube of each set shall be tested at seven days and the remaining two at 28 days after casting. The test cubes shall be made from a representative batch of concrete as that used for the piling works and each cube shall be properly marked and identified with details relating the specimen to the borehole in which the concrete is used.

Test shall be carried out by approved lab. Test results shall be submitted to the Engineer within 48 hours after testing.

The Contractor shall not carry out the specified cube strength tests without prior notice to the Engineer. The tests must be witness by the Engineer or his representative. The contractor shall provide sufficient quantity of all necessary equipment at site to carry out these tests.

(d) Workability

Slump test shall be undertaken for every truck load of concrete. Slump measured at the time of discharge into pile shaft or at the time of discharge into the concrete pump hopper shall be in accordance with the standards shown below unless otherwise approved. A concrete pump shall not be used to place tremie concrete directly into the pile shaft.

Class of Slump (mm) Workability		Typical Conditions of Use
A	100 ± 25	Where concrete is to be placed in water-free shaft.
B	175 ± 25	Where concrete is to be placed by tremie method under drilling fluid.

The concrete for piles shall be as specified in the design requirement with suitably enriched cement content to permit a high slump mix. Alternatively, the Contractor may incorporate an approved set retarding additive into the mix to ensure extended workability of the concrete after placement. It is held that the Contractor has included these provisions in the unit rate for the pile.

(e) Failure of Concrete Cube Tests

If the concrete cubes as tested failed to satisfy the criteria as prescribed in Specification, the Contractor shall undertake all necessary additional and consequential remedial/compensatory Work to the approval of the Engineer. The piles shall be rejected as in Clause 1.8 "Rejected Piles".

2.4 Pile Excavation

(a) Pile size and length

The Contractor shall carry out own tests along the proposed wall alignment to determine the bedrock level. Probing of bedrock shall be carried out along the proposed wall line at intervals to be agreed by the Engineer.

(b) Boring near recently Cast Piles

Piles shall not be bored next to other piles which have recently been cast less than 24 hours or contain unset concrete, whichever longer to avoid damage to any of these piles.

(c) Stability of Boreholes

It is held that the Contractor has allowed in the unit rate of the pile for the implementation of all necessary measures, including the provision of all materials, labour and plant, for maintaining the stability of the sides of boreholes during bored pile installation and successful completion of the piles. The Contractor shall submit his proposed methods for agreement prior to commencement of boring operations.

Irrespective of the presence of ground water, the sides of all borehole shall be kept intact and no loose material shall be permitted to fall into the bottom of the boreholes. The Contractor's boring equipment shall be able to sink a steel casing to support the sides of all boring.

If the sides of boreholes are found to be not stable, temporary steel casing shall be driven into stable stratum. The borehole shall be filled with drilling fluid to a level sufficiently to stabilise the boreholes.

If ground water is found in any hole in sufficient quantity or gushing out as to affect boring operations or excavations and removal of soil from the boreholes, or the sides of boreholes collapse, then a steel casing of appropriate size and length in conjunction with stabilising fluid or other alternatives of sufficient strength shall be used to support the sides of the borehole and permit boring operations to proceed smoothly and safely. The proposed drilling fluid mix must be submitted to the Engineer for approval.

Excavations shall not be exposed to the atmosphere longer than is necessary and shall be covered at all times when work is not in progress. Pile excavated shall be casted within 24 hours unless otherwise agreed by the Engineer.

In the event of a rapid loss of drilling fluid from the borehole excavation and caused instability of bore, the excavation shall be backfilled without delay or other appropriate and approved remedial measures taken by the Contractor like installing temporary casing prior to resuming boring at that location.

(d) Stability of bore by temporary casing method

Where the use of a temporary casing is required to maintain the stability of a bore, the bottom of casing shall be kept a minimum of 1 metre or more below the unstable strata to prevent the inflow of soil and the formation of cavities in the surrounding ground.

Temporary casings shall be thin walled mild steel cylindrical casing, spirally welded or other similar construction. The dimensions and quality of the casing shall be adequate to withstand without damage or distortion all handling, construction and ground stresses to which they will be subjected, including preventing concrete from within the pile from displacing soft soil or soil squeezing in and displacing fresh concrete. The casings shall have an internal diameter not less than the specified pile diameter. They shall be free of significant distortion, of uniform cross-section throughout each continuous length and free from internal projections and encrusted concrete which might prevent the proper formation of piles. The joints of casings shall be reasonably watertight.

If temporary casings are damaged during installation in a manner which prevents the proper formation of the pile, such casings shall be withdrawn from the bore before concrete is placed, repaired if necessary, or other action taken as may be approved to continue the construction of the pile.

(e) Rock Coring

Rock coring shall mean coring of sound bedrock using a coring bucket or approved method. The used of chisel shall not cause loosening or collapse of borehole. Coring of rock other than two items specified below shall not be considered as coring in rock, and will only be considered as boring in soil.

- (i) Rock socket length
- (ii) Cavity roof

Coring of inclined rock surface, limestone pinnacles, cavities and soil below boulder/floater shall be considered as boring in soils.

Socket length shall be measured from the flattened horizontal bedrock surface. This flat horizontal surface shall be probed using kelly bar or steel bar at a minimum of five positions over the borehole to confirm sound bedrock for socketing.

(f) Spillage and Disposal

All reasonable steps shall be taken to prevent the spillage of drilling fluid on the site in areas outside the immediate vicinity of boring. Discarded drilling fluid shall be removed from the site without delay. In disposal of unwanted drilling fluid, the Contractor shall

comply with government regulations and shall propose a proper disposal method to be approved by the Engineer.

(g) Inspection of Pile Excavation

Where practicable, all pile excavations shall be inspected for their full length before concreting. The Contractor shall provide all the apparatus necessary for the inspection.

Inspection shall be carried out either from the ground level or below ground level at the sole discretion of the Engineer prior to concrete being placed in the borehole. For such inspection to be carried out safely, the Contractor shall provide all facilities and assistance to enable the said inspection to be done. In the course of inspection any loose or soft material in the borehole which is likely to affect the performance of the pile shall be removed to the satisfaction of the Engineer.

In the case of inspection from ground level, the base of the boring shall be inspected by approved method for wet hole and means of a light for dry hole to ensure that all loose, disturbed and/or remoulded soil is removed and that the sides of the boring will remain stable during the subsequent concreting operations. The verticality and position of the boring shall be checked to ensure that they meet the specified tolerances.

Inspection below ground level shall be carried out for piles with shafts of 760mm (2'6") diameter and above. For this purpose the Contractor shall, apart from providing other safety measures, also provide the required facilities such as an approved type of a steel safety cage with an air-line, lifting cable and hoist, gas detector, lights, etc. to enable descent into and ascent from the borehole to be carried out safely without any danger to life. In this regard the safety precautions described in CP 2011:1969 "Safety Precautions in the Construction of Large Diameter Boreholes for Piling and Other Purposes" shall generally be followed, unless otherwise directed by the Engineer.

(h) Pumping from Bored Hole

Pumping from boreholes may be carried out from time to time on a number of piles designated by the Engineer to verify the suitability of dry hole construction, or to investigate and rectify a cold joint in a pile shaft where concreting has been interrupted.

No pumping from a borehole shall be permitted unless a casing has been placed into the stable stratum which prevents further ingress of water of significant quantity from other strata into the borehole, or unless it can be shown that pumping will not have a detrimental effect on the surrounding soil or hamper the piling operation in any way.

(i) Cleaning Out

Upon completion of boring the excavation shall be cleaned of all loose, disturbed and or remoulded soil and sediment soil to expose a firm base of undisturbed material using a suitable and effective method to be approved by the Engineer.

(j) Continuity of Construction

A pile constructed in a stable soil without the use of temporary casing or other support shall be bored and concreted without prolonged delay to ensure that the soil characteristics are not significantly altered.

(k) Surface Water

All boreholes shall be protected from the possibility of any surface water entering the hole from time to time and until the hole is completed and ready to be concreted.

(l) Excavation Materials

Surplus earth resulting from piling operations shall be used where required or removed from site as directed by the Engineer.

2.5 Placement of Reinforcement

Reinforcement shall be free from rust and mud and not be placed until inspected and accepted.

Reinforcement cages shall be sufficiently rigid to ensure that they remain at their correct level during the lifting and placing of the concrete and the extraction of temporary lining tubes.

Reinforcement shall be maintained in its correct position during concreting of the pile. The minimum cover to all reinforcement shall not be less than 75mm.

Concrete spacer shall be provided at every 3m interval, size and minimum yield strength of reinforcement shall be as specified in the Drawing. Details by which the Contractor plans to ensure the correct cover to and position of the reinforcement shall be approved by the Engineer.

The main longitudinal reinforcing bars in piles not exceeding 12 metres in length shall be in one continuous length unless otherwise specified. In piles longer than 12 metres and required to be reinforced throughout their full lengths when specified, joints with staggered laps of alternate bars will be permitted in main longitudinal bars at 12- metre nominal intervals unless otherwise specified in the Drawings. Joints in reinforcement shall comply with the specific requirements of BS8110 clause 3.12.8.

The Contractor shall submit for approval a method statement on the manner by which he intends to lower reinforcement cages into pile shafts. Where tack welding is carried out on pile reinforcement for the purpose of hoisting, such welding shall be located only within the top 100mm of each reinforcement cage. Where the top of a reinforcement cage being lowered is to be lapped to the next cage, as in the case of tension piles exceeding 12 metres in length, the Contractor shall provide adequate sacrificial steel to compensate any lapped reinforcement which has been tack welded, where such tack welding is the requirement of the Contractor for his hoisting operation. Sacrificial steel shall be of the same grade and size as that of the compensated bar.

If required by the Engineer, reinforcement cages shall be flushed with fresh water to remove accumulated salts or other deposits immediately prior to lowering into the pile shaft.

2.6 Concreting in Wet Hole

Immediately after the boring for the pile has been completed, approval to commence concreting shall be sought and, when this has been obtained, concreting shall start forthwith and continue without interruption. All concrete for cast-in-place piles shall be compacted to produce a dense homogeneous mass by a method agreed by the Engineer.

Concrete to be placed under drilling fluid shall be placed using a tremie concrete pipe in accordance with BS 8004, Clauses 7.4.5.4.2 and 8.2.2.3.4. Where discrepancies arise, the provisions of this specification shall take precedence.

Alternative methods of placing concrete such as the use of a drop bottom bucket or hose from a concrete pump will not be accepted by the Engineer. At no stage concrete be permitted to discharge freely into drilling fluid.

Before placing concrete, agreed measures shall be taken by the Contractor to ensure that there is no accumulation of contaminated drilling fluid, silt or other deleterious material at the base of the bore. Contaminated drilling fluid could impair the free flow of concrete from the tremie pipe and affecting the performance of the pile.

A sample of the drilling fluid shall be taken from the base of bore using an accepted sampling device. If the drilling fluid does not comply to the specification, concrete placement shall not proceed and the Contractor shall modify or replace the drilling fluid to meet the requirements of this specification.

The tremie concrete pipe shall consist of a series of metal pipes with internal diameter not less than 250mm. The receiving hopper shall have a capacity at least equal to that of the pipe it feeds. At all times, a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from concrete exceeds that from the water or drilling fluid.

The hopper and pipe of the tremie shall be clean and watertight throughout. The pipe shall extend to the base of the bore and a sliding plug or barrier placed at the discharge outlet of the pipe to prevent direct contact between the first charge of concrete in the tremie pipe and drilling fluid. If the plug or barrier is sacrificial, it shall not be retained in the mass of the concrete.

The tremie pipe outlet shall be kept at least 1.5 metres below the surface of the concrete at all stages in the pour. The Contractor shall develop a system of level checks for the concrete and pipe outlet to ensure that this requirement is met. The tremie pipe shall be withdrawn upward gently behind the concrete level, and shall not be given any violent movement either in dislodging the concrete within the pipe or for any other reason.

Concrete placement shall be halted should a delay or breakdown occur during the concreting operation which in the opinion of the Engineer, could cause a cold joint, entrapment of latency in the tremie concrete, or otherwise lead to defective concrete. Before the remainder of the pile shaft can be concreted, the pile shall be dewatered and the top surface of the tremie concrete cut back to sound concrete and cleaned of all laitance and weak concrete. The remainder of the pile shall either be cast by tremie or in the dry, as directed by the Engineer. If this remedial work can not be carried out due to construction difficulty, the Contractor will need to construct a replacement pile.

The concrete for each pile shall be from the same source. The Contractor is to ensure that the supply from whatever source (whether site-mixed or ready-mixed) is of sufficient quantity so that concrete for each pile shall be placed without such interruption.

All holes bored shall be concreted within the same day. In the event of rain, the Contractor is to provide adequate shelter to keep the hole dry and to concrete under cover.

The method of placing and the workability of concrete shall be such that a continuous monolithic concrete shaft of the full cross-section is formed. The method of placing shall be approved by the Engineer. The Contractor shall take all precautions in the design of the mix and the placement of concrete to avoid arching of the concrete in the pile shaft. No spoil, liquid or other deleterious matter shall be allowed to contaminate the concrete.

Temporary casings shall be extracted while the concrete within remains sufficiently workable to ensure that the concrete is not lifted and that the resultant pile is continuous and of full section. Temporary casings shall be extracted in not more than 2 hours after concreting has completed.

When casings and linings are withdrawn as concreting proceeds, a sufficient head of concrete shall be maintained to prevent the entry of ground water which may cause reduction of cross-section of the pile. No concrete shall be placed after the bottom of the casing or lining has been lifted above the top of the concrete. Concrete 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 the withdrawal of casing could result in excess heads of water or drilling fluid. Excess pressure heads are caused by the displacement of water or fluid by concrete as the concrete flows into its final position against the wall of the shaft. Precautions such as the use of two or more discontinuous lengths of casing (double casing) shall be deemed an acceptable method of construction in this case.

In the event of the ground water level being higher than the required pile head cut-off level

shown in the contract drawings, the Contractor shall submit his proposals for agreement prior to placing concrete. The pile head shall not be let below the ground water level unless adequate and agreed precautions are taken.

The top of the pile shall be brought above the required cut-off level by an amount sufficient to ensure a sound concrete at cut-off level and the surplus removed to ensure satisfactory bonding of the pile head to the structure.

The actual volume of concrete used for each pile must be measured with the calculated volume required. If the difference between these two volumes indicates a possible necking, the Contractor shall propose and carry out appropriate tests and measures to the approval of the Engineer to ensure the adequacy of the pile.

Backfilling of Empty Bore - On completion of concreting, the remaining empty bore shall be backfilled with sand or lean concrete unless otherwise agreed by the Engineer.

Any consequences causing the pile rejected by the Engineer due to supply of concrete shall be on contractor's own risk.

2.7 Stripping Pile Heads and Bonding

The piles shall be constructed to a sufficient height above the required cut-off levels ('overcast') to ensure that all concrete at and below cut-off level is homogeneous and free of laitance and deleterious matter. The Contractor shall be required to provide adequate reinforcement with sufficient length to project above cut-off levels so that the reinforcement can be properly bonded in the capping beam. After completion of piling, the Contractor shall excavate and cut back the piles as necessary to verify the cut-off levels and to give accurate details of the pile positions as compared with the positions indicated on the pile layout plans of the detailed design. Defective concrete in pile heads shall be cut away and made good with new concrete well bonded to the pile head. If the pile is undercast, it shall be built-up with new concrete and a permanent casing.

2.8 Drilling Fluid and Soil Tests

Minimum frequency of testing are as follows:

- 1) fresh drilling fluid
- 2) drilling fluid taken from the bottom of the pile before concreting
- 3) recycle drilling fluid taken from desanding machine
- 4) drilling fluid left in the bored hole for more than 12 hours

The frequency of testing drilling fluid and the method and procedure of sampling shall be proposed by the Contractor and agreed by the Engineer before the commencement of the work. The frequency may subsequently be varied with the approval of the Engineer. Control tests for density shall be carried out daily on the drilling fluid using suitable apparatus. The measuring device shall be calibrated to read within 0.01 g/ml. The results shall be within the ranges stated in Table 2.1.

All reasonable steps shall be taken to prevent the spillage of drilling fluid on the site. Discarded drilling fluid shall be removed from the site without delay and such removal shall comply with the regulations of the relevant Authorities.

If sand content more than 5%, Contractor shall carried out desanding to screen out sand from drilling fluid before concreting.

TABLE 2.1 - TESTS FOR BENTONITE DRILLING FLUIDS

Property to be measured	Compliance values measured at 20°C	Test Method/Apparatus
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Density	Less than 1.10g/ml	Mud Density Balance
Fluid Loss	Less than 40ml	30 minutes test
Viscosity	30-90 seconds or less than 20cP	Marsh Cone method Fann Viscometer
Shear Strength (10 minutes gel strength)	1.4 - 10N/m ² or 4 - 40N/m ²	Shearometer Fann Viscometer
Sand Content	Less than 5%	Screen
pH	9.5 – 12	pH indicator paper Strips or electrical pH meter

Note : Where the Fann Viscometer is used, the fluid sample should be screened by 300µm sieve before testing.

Tests for drilling fluid other than bentonite have to be approved before use.

2.9 Dry Hole Construction (If directed by the Engineer Only)

For the purpose of the tender, the boreholes for pile construction shall be assumed to be wet holes, where the tremie method of concreting shall be adopted.

However, during pile installation as directed by the Engineer, the Contractor shall be required to determine for a number of designated piles whether dry hole construction could be implemented. The accepted method for dry hole verification shall be to pump out all water in the hole, and observe the rate of water intrusion and to be decided by the Engineer.

Whenever practicable, concrete for bored piles may be placed into a clean, dry hole. All dry holes shall be inspected and approved by the Engineer prior to placing of concrete. All facilities, labour and material required for the inspection shall be provided by the Contractor.

Agreed measures shall be taken to avoid segregation and bleeding, and that the concrete at the bottom of the pile is not deficient in grout. The concrete shall be placed by tremie. The free fall of the concrete from the bottom of the tube shall not exceed 1.5 times the diameter of the pile. The concrete shall be placed as quickly as possible where the ground is liable to deteriorate on exposure.

2.10 Pile Acceptance Criteria

The target termination depth, required socket length, concrete strength and the required working pile capacities are as shown in the drawings. The actual termination depths and socket lengths shall be agreed with the Engineer based on review of the conditions encountered during boring and prior to commencement of concreting. Piles shall meet tolerance requirements as specified in Clause 1.3 and satisfying integrity tests as specified in Clause 3.0.

2.11 Casting Level

Concrete shall be finished not less than 300mm above the cut-off level ('overcast') to ensure that all concrete at and below cut-off level is homogeneous and free of laitance and deleterious matter. A thicker overcast may be required by the Engineer depending on site condition, and

this shall be carried out. The overcast shall be chipped off to cut-off level later by the Contractor.

2.12 Defective Concrete

Defective concrete in the pile heads shall be cut away and made good with new concrete well bonded into the old concrete.

2.13 Piling Records

Submission of the record shall be in accordance with Clause 1.9 herein.

The record shall contain all information required by the Engineer including the following:

- Name of Supervisor
- Pile forming equipment including Rig No.
- Length, diameter and reference number of the borehole
- Existing ground level
- Cut-off level, rock level, pile toe level
- Length of pile
- Log of material encountered and level of change in strata and where boring stops
- Speed of boring through soil or rock shall be recorded for every metre of drilling
- Depth bored and details of inclination or displacement of the pile during boring and date of inspection
- Length of reinforcement cage, reinforcement details
- Water table below ground level
- Levels where seepage occurs
- Results of tests on soils
- Results of tests on concrete cubes (slump test)
- Length of temporary casing if used
- Date and actual volume of concrete placed in piles, time start and complete
- Concrete level after each truck of concrete
- Details of all inspections
- Details of all obstructions, delays and other interruption
- Signature of the Resident Engineer or his representative
- Weather condition
- Method of casting (wet/dry tremie)
- Date and time boring start and complete and speed of drilling
- Type of stabilising fluid
- Collapse of bore or loss of drilling fluid
- Cavities or slump zones encountered

2.14 Treatment of Cavities and Slump Zones

The specification for treatment of cavities and slump zones should be followed unless otherwise instructed by the Engineer.

3.0 INTEGRITY TESTING OF PILES

3.1 General

Piles shall be selected by the Engineer for testing and detection of major faults, necking, discontinuities, and cross sectional areas of the piles. Integrity testing of piles shall be carried out by an independent testing organisation approved by the Engineer.

If the results of the tests show that the pile or piles are defective, the pile or piles shall be treated

as faulty and shall be rejected unless the Contractor can demonstrate to the approval of the Engineer effective remedial measures that will be carried out.

The results of tests shall be printed out immediately during tests with printer facility at site and submit to Engineer at site. The Engineer's interpretations and conclusions arrived at on the test results shall be final.

Working piles shall be subjected to shock method and sonic logging tests.

3.2 Shock Method

(a) Preparation of the Pile Head

The pile head shall be clearly exposed, free from debris, etc. and not more than 1.0 metre above or below ground level, otherwise the surrounding soil shall be built up or excavated to meet this condition. The pile head shall be smooth over its complete cross-section, free from irregularities and perpendicular to the vertical axis of the pile.

The pile head shall consist of sound concrete. This shall be achieved during the concreting of the pile by flushing out all weak mortar, etc. from the top of the pile head and carefully screeding off to provide a smooth level surface in sound concrete. Alternatively, if the pile head is prepared after concreting, all weak mortar, broken concrete, etc. shall be removed from the pile head to expose sound concrete over its complete cross-section. After cleaning it off to ensure a sound bond, a very thin screed (maximum 1cm) of strong sand/cement mortar, rapid hardening compound, shall be spread to provide a smooth working surface for the shock test equipment. The mortar shall be allowed to harden before testing.

Any reinforcement or other inclusions protruding from the pile head shall not prevent the testing team from giving the pile the required impact force over the centre of the pile and the placing of a 5cm diameter (approx.) electronic pick-up at about 10cm from the periphery of the pile. Access shall be provided for the service van within 30 metres of the pile.

(b) Shock Test Equipment

The shock which is to be imparted onto the pile head shall be carried out using a suitable hammer or any approved method which is capable of transmitting vibration to the base of the pile shaft. The electronic pick-ups located on the pile head shall be approved velocity transducers or accelerometers connected through an approved frequency analyser to a X-Y plotter. The mechanical admittance shall be plotted on a vertical scale and the frequency on the horizontal scale. Both the horizontal and vertical scales shall be varied as required. The equipment shall have an independent power supply.

(c) Shock Test

The Contractor shall provide the qualified and experienced testing team with a site plan showing the pile layout and a list of the piles to be tested.

Before testing, the heads of the piles shall be inspected by the testing team for regularity and soundness and any unsatisfactory pile heads shall be reported to the Engineer. They shall be made good to the satisfaction of the Engineer and smoothed off using a suitable epoxy mortar if necessary. Preliminary tests shall be carried out to establish the appropriate scales and to check the electronic circuit.

3.3 Sonic Logging Method

For the purpose of carrying out sonic logging, the Contractor shall be required to install the necessary tubing for the tests at all pile locations or as directed by the Engineer.

The tubes shall be of internal diameter not less than 50mm with no internal projections or couplings. They can be of mild steel pipes. Four (4) nos. of tubes are required for each pile greater than 700mm diameter while two (2) nos. are required for each smaller diameter pile.

The tubes shall be fixed to the longitudinal bars with equal spacing on the inside perimeter of the links. The tubes shall be watertight with the bottom of the tube sealed and suitably weighted to prevent floating. The tubes shall be secured to the internal face of the reinforcement cage at equal distance from each other on the circumference.

The tubes shall extend the full depth of the pile and project 300mm above the top of the concrete and not lower than 300mm below the surface of the ground. All joints shall be made watertight. The tubes shall be filled with water to provide the necessary acoustic coupling, and then plugged or capped before concreting. The type of tube and condition of sealing shall be checked and approved by the Engineer before installation.

The rate of logging for increments of depth shall be approved by the Engineer.

After conducting the tests, all tubes shall be grouted with approved strength and water in the tubes displaced. The grout shall be dense cement grout with an approved expanding agent.

Prior to testing, the necessary equipment shall be thoroughly checked to ensure that all parts are functioning satisfactorily. During sonic logging testing, where any irregularities are detected, the tests shall be repeated at a smaller scale to allow a 'close-up view' of the irregularities.

Presentation of Test Results

The time required to carry out the test for each pile must be recorded along with records of starting time and finishing time.

The results of the tests shall be presented in report by the testing firm and must be signed by a professional engineer. The report shall include comprehensive engineering analysis of the test results for each pile taking into consideration the soil condition and any other relevant factors. Interim reports of each pile or group of piles tested in one day shall be submitted to the Engineer within 2 days of the completion of the test or tests. A final comprehensive report shall be submitted to the Engineer within 7 days of the completion of the last test or tests.

3.4 Proof Coring of Pile Shafts

The Contractor shall check the quality of the concrete in the shafts of working piles as directed by the Engineer. This shall be achieved by a vertical diamond core hole drilled through the centre region of the pile from pile head to required depth. The location of the drill hole and depth shall be approved by the Engineer. Full core recovery shall be attempted. The core so produced shall not be less than 50mm in diameter. The minimum number of piles for proof coring test shall not be less than 1% of the total number of working piles or as specified in the Bill of Quantities.

For each pile to be cored, the coring work shall be completed before the concrete in the pile has reached an age of 28 days to allow the cores to be tested for unconfined compression tests at 28 days. The Engineer shall mark the sections of the core to be tested and the Contractor shall arrange for testing in an approved laboratory. A minimum of six(6) unconfined compression tests shall be conducted on cores obtained from a pile. Additional number of the unconfined compression tests may be requested by the Engineer if in the opinion of the Engineer the quality of the concrete of the pile is doubtful.

The cored hole in the pile shall be grouted after testing. The grout shall be an approved dense

cement grout with a minimum 28 days strength of equal or higher than the strength of the concrete of the bored pile. If the pile is found to be faulty in the opinion of the Engineer because of defects such as cracks, overbreaks, necking, cavity, inclusion of foreign deleterious materials, poor quality concrete, etc., the pile shall be rejected and the Contractor shall undertake all necessary remedial measures to the approval of the Engineer.

In conjunction to core testing, the Engineer may request sonic logging test to be conducted in the cored holes or pre-installed tubings to determine the in-situ density of the pile and their integrity continuously along the pile length in correlation with core samples.

3.5 Instrumentation and Monitoring for Piles

The instrumentation and monitoring for the contiguous bored piles shall be carried out following the Specification for Instrumentation and Monitoring for Retaining Structures and Excavation.

- (a) Inclinometers shall be installed in working pile to monitor the lateral deformation of pile. The number of inclinometers to be installed are specified in the Bill of Quantities
- (b) Instrumentation Installation

The Contractor shall follow the manufactures' recommended procedures for instruments installations and shall provide with a method statement for approval prior to installation. The work shall be carried out by persons experienced in this type of work. A data logging system shall be provided for automatic recording of all instruments.



TABLE OF CONTENTS

	Description	Page
1.0	GENERAL	CBP1
1.1	Works in accordance with Specifications	CBP1
1.2	Setting Out	CBP1
1.3	Tolerances	CBP1
1.4	Person in Charge	CBP2
1.5	Piling Equipment and Accessories	CBP2
1.6	Sequence of Installation of Working Piles	CBP2
1.7	Forcible Correction Not Permitted	CBP2
1.8	Rejected Piles	CBP2
1.9	Records	CBP2
2.0	BORED CAST IN-PLACE PILES	CBP2
2.1	General	CBP2
2.2	Tolerances	CBP3
2.3	Concrete	CBP3
2.4	Pile Excavation	CBP4
2.5	Placement of Reinforcement	CBP7
2.6	Concreting in Wet Hole	CBP8
2.7	Stripping Pile Heads and Bonding	CBP9
2.8	Drilling Fluid and Soil Tests	CBP10
2.9	Dry Hole Construction (If directed by the Engineer Only)	CBP11
2.10	Pile Acceptance Criteria	CBP11
2.11	Casting Level	CBP11
2.12	Defective Concrete	CBP11
2.13	Piling Records	CBP11
2.14	Treatment of Cavities and Slump Zones	CBP11
3.0	INTEGRITY TESTING OF PILES	CBP12
3.1	General	CBP12
3.2	Shock Method	CBP12
3.3	Sonic Logging Method	CBP13
3.4	Proof Coring of Pile Shafts	CBP14
3.5	Instrumentation and Monitoring for Piles	CBP15