



Ministry of Housing, Construction & Public Utilities

***SPECIFICATIONS
FOR
BORED AND CAST IN-SITU
REINFORCED CONCRETE
PILES***



ICTAD

**Institute for Construction Training and Development
"Savsiripaya"
123, Wijerama Mawatha,
Colombo 07**

Publication No. ICTAD/DEV/16
First Edition - April 1997

MINISTRY OF HOUSING, CONSTRUCTION AND PUBLIC UTILITIES

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FOREWORD

Under the corporate activity of developing documents on construction related works, ICTAD has identified the necessity of having specifications for Bored and Cast In-situ Reinforced Concrete Piles and hence initiated the formulation of this guidelines.

This guide extracts the appropriate specifications used in other countries with due consideration to practical applications in Sri Lanka. This document will be a useful guide for the personnel involved in Construction Industry, particularly Geotechnical Engineers involved in Foundation Design.

This specification was published by the Technology Development Division of ICTAD and was drafted by a panel of experts from Sri Lanka Geotechnical Society, under the guidance of well experienced group of professionals in the Construction Industry.

I acknowledge with grateful thanks the service of the members of the drafting panel of Sri Lanka Geotechnical Society and the Review Committee Members in the publication of the Specification.

Prof. Dayantha S Wijeyesekera

Chairman

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DISCLAIMER

Whilst all care and efforts have been made to ensure the proper production of this document and its contents, neither does the Drafting Committee nor the ICTAD accept any liability for problems, Difficulties or Controversy arising from the usage of these guidelines.

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SECTION 1

GENERAL CONDITIONS SPECIFIC TO PILING WORK

This section must be read in conjunction with the following ICTAD publications:

- (i) ICTAD Publication No. SCA/1 of January 1989 on 'Conditions of Contract for works of Building & Civil Engineering - Sri Lanka'.
- (ii) ICTAD Publication No. ICTAD/ID/04 on 'Preliminaries Bill No.1 (Specimen Bill)'

1.01

INFORMATION

Information and requirements specific to the particular Piling contract are given in Schedules 1 and 2 which form part of the specifications.

1.02

STANDARDS

All materials and workmanship shall be in accordance with the appropriate Sri Lankan Standards, or the current British Standards which are listed in Appendix 1.1. Where these standards are in conflict with this specification, the latter shall take precedence.

1.03

MATERIALS

1.03.1

Sources of Supply

The Engineer's approval should be obtained for the sources of supply of materials, and they shall not be changed without prior approval.

1.03.2

Rejected Material

Clause 39(1) of ICTAD Publication No. SCA/1 (1989) shall apply.

1.04

SAFETY

- (i) Safety operations through out the piling operations shall comply with BS 8004 and BS 5573 of the British Standards.
- (ii) All open pits and boreholes should be covered.
- (iii) The site should be kept clear of unnecessary obstructions such as spoil heaps, discarded wire ropes, reinforcement bars, timbers with protruding nails, etc.

1.05 SITE CONDITIONS

1.05.1 Soil Investigation Reports

Factual information and reports on Site Investigations for the Works are given as an Annexure. However, no responsibility is accepted by the Owner or the Engineer for any opinions or conclusions given in the reports.

1.05.2 Unexpected ground conditions

Whilst conforming to Clause 12 of ICTAD Publication No. SCA/1 (1989), it is emphasised that the Contractor shall report immediately to the Engineer any circumstances which indicate that in the Contractor's opinion the ground conditions differ from those inferred by him from his interpretation of the Site Investigation Reports.

1.05.3 Site details

Clause 11 of ICTAD Publication No. SCA/1 (1989) shall apply.

1.05.4 Site Surface

- (i) In sites such as those where fill material lie above soft compressible sub-soils, the Contractor shall make his own arrangements for any additional filling that may be necessary so that the movement of his piling equipment will not be hindered during the progress of works. The Contractor should allow for costs in his rates for any special surfacing he may require for his piling rigs.
- (ii) The Contractor shall be responsible for keeping the site in a dry, well drained and safe condition.

1.05.5 Claims

Unless agreed by the Engineer as unforeseen conditions, no claims for standing time of rigs, equipment, etc., and no extension for contract time shall be allowed on account of naturally occurring obstructions encountered at site.

If boulders are anticipated, then a rate for drilling through boulders should be provided for in the BOQ; and if boulders far in excess of those anticipated at the time of tendering are encountered during the drilling operation, then a reasonable extension of time for this work shall be allowed for by the Engineer.

1.06 TOLERANCES

1.06.1 Setting out

Setting out shall conform to Clause 17 of ICTAD Publication No. SCA/1 (1989), and shall be carried out from the main grid lines of the proposed structure. Immediately before installation of the pile, the pile position shall be marked with suitable identifiable pins or markers.

1.06.2 Positions

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 will be permitted in accordance with clause 1.06.3.

1.06.3 Verticality

The maximum permitted deviation of the finished pile from the vertical is 1 in 75.

1.06.4 Forcible corrections

Forcible corrections to concrete piles shall not be made.

1.06.5 Rectification for incorrect placing

- (i) If one or more piles deviate from the allowable tolerances, the Engineer may decide that additional piles shall be placed and/or that the foundation construction shall be strengthened or extended.
- (ii) Piles which have been cast deeper than specified should be extended upwards to the required level.
- (iii) The cost for all additional works resulting from incorrectly placed piles shall not be reimbursable to the Contractor. This includes the cost of additional piles, calculations, and testing.

1.07 PILING OPERATIONS

1.07.1 Piling Method

The Contractor shall supply for approval of the Engineer all relevant details of the method of piling and the plant he proposes to use.

1.07.2 Equipment and Labour

- (i) The Contractor shall provide all frames, equipment, lifting devices and labour necessary for the installation and testing of piles.
- (ii) The piling works shall be carried out by operators and supervisory staff thoroughly experienced with the system.
- (iii) The Engineer shall order the removal or replacement of any equipment or staff whenever in his opinion such equipment and staff are not suitable for the execution of the Works.

1.08 PERFORMANCE SPECIFICATION

- (i) Where piling is required to meet a performance specification the Contractor shall, when tendering, supply full details of the type of pile offered, the standards of control he intends to use, how the calculation and the checking of the load bearing capacity and settlement of the piles will be carried out, and the tests he proposes to undertake on the site.
- (ii) The performance specification applicable to the piling contract is given in Schedule 2.

1.09 ALTERNATIVE PILING SYSTEM

The Contractor may submit at the time of tendering any other alternative piling system. In the alternate system offered, the Contractor must include together with his tender

- (a) Design calculations, including the load carrying capacity of the piles
- (b) Specification for the alternative system offered
- (c) Pile arrangement
- (d) Description of the system

1.10

FULL RESPONSIBILITY OF THE CONTRACTOR

Notwithstanding approval or acceptance by the Engineer of the Contractor's proposals and specifications or the acceptance of a proprietary piling system, it shall be the Contractor's full and sole responsibility to install piles suitable to perform the required function and to comply with all the standards given in the specifications.

1.11

PILING PROGRAMME

Clause 14(1) of ICTAD Publication No. SCA/1 (1989) shall apply.

1.12

RECORDS AND REPORTS

1.12.1

Daily records

The Contractor shall keep and submit to the Engineer a daily record of the pile installation work carried out. The complete record shall include:

1. Pile Reference Number
2. Location
3. Pile Type
4. Nominal cross sectional dimensions or diameter
5. Nominal size of underream
6. Standing groundwater level
7. Date and times of boring
8. Date of concreting
9. Ground level at commencement of installation of pile
10. Working level
11. Depth from working level to base of pile
12. Base level
13. Depth from working level to top of pile
14. Length of temporary casing
15. Length of permanent casing
16. Soil samples taken and in situ tests carried out
17. Length and details of reinforcement
18. Concrete mix.
19. Volume of concrete supplied to the pile where this can be measured in practice.
20. All information regarding obstructions, delays and other interruptions to the sequence of work.
21. Details of drilling mud, when used
22. Details of Tremie construction, when used
23. Any other information required by the Engineer.

Typical formats which could be used are given in Appendix 1.2.

1.12.2 Progress Report

The Contractor shall submit to the Engineer on the first day of each week, or at such longer periods as the Engineer may from time to time direct, a progress report showing the current rate of progress and progress during the previous period on all important items of each section of the works.

1.12.3 'As Built' Drawings

On completion of piling operations, the Contractor shall submit to the Engineer a set of 'As Built' Drawings to a scale of 1:100 indicating

- (i) Pile layout
- (ii) For each pile - Ref. No., Location, Pile Type, Nominal diameter, cut-off level, finished level

1.13 NUISANCE AND DAMAGE

1.13.1 Noise and Disturbance

The Contractor shall carry out the work in such a manner and at such times as to minimize noise and disturbance.

1.13.2 Damage to adjacent structures

If during the execution of the work damage is, caused to mains, services, or adjacent structures, the Contractor shall repair such damage at his own expense.

1.13.3 Damage to Piles

The Contractor shall ensure that damage does not occur to completed piles. The Contractor shall submit to the Engineer his proposed sequence and timing for boring piles having regard to the avoidance of damage to adjacent piles. A minimum number of days shall be provided before boring adjacent to a freshly cast pile, as per Clause 3.04.1.

Where a pile has been damaged or displaced during installation, testing or by other causes, the damaged or displaced pile shall be considered and treated as a faulty pile. The Contractor shall bear the cost of all remedial work occasioned by such rejection of piles to be determined by the Engineer.

1.14 BASIS OF PAYMENT

1.14.1 Pay-length of piles

- (i) The pay-length for the piles shall be the length between the toe of the pile and the specified cut-off level.
- (ii) Payment for a pile shall be based on the pay-length multiplied by the unit rate.

The Contractor shall allow in his rates for all materials, equipment, tools; for all personnel; and for all works incidental to the installation and completion of piling works; and for any wastage.

1.14.2 Provisional Pile length

For tendering purposes, a provisional pile length based on an average anticipated depth of piling shall be assumed. This provisional pile length is based on information obtained from the Site Investigation. Nonetheless it shall be the Contractor's responsibility to anticipate and to determine the actual length which may be required for each pile.

1.15 GENERAL REQUIREMENTS

1.15.1 Temporary fencing

Clause 19 of ICTAD Publication No. SCA/1 (1989) shall apply.

1.15.2 Advertisements

The Contractor shall allow no advertisement to be placed on any hoarding, scaffolding or fencing erected in connection with the Contract without the permission of the Engineer.

1.15.3 Latrine and washing accommodation

Latrines and washing accommodation shall be in accordance with Preliminary Item No. 109 of ICTAD/ID/04.

1.15.4 Telephone facilities

The Contractor shall make his own arrangements with the appropriate authorities for the provisions of telephone facilities to and on the site.

1.15.5 Flammable Stores

All petroleum, explosives and flammable materials shall be stored in fireproof buildings and such precautions taken with regard to siting and fire risks as the Engineer may direct. The Contractor shall make all arrangements with the licensing authority for the necessary license.

1.15.6 Cleaning up

Clauses 32 and 33 of ICTAD Publication No. SCA/1 (1989) shall apply.

Appendix 1.1

RELEVANT BRITISH STANDARDS

1. Site Investigations

- BS : 5930 Code of practice for Site Investigation
BS : 1377 Methods of test of Soil for Civil Engineering purposes

2. Materials

- BS : 12 Specification for Ordinary & Rapid - hardening Portland Cement
BS : 882 Specification for Aggregate from Natural sources for concrete
BS : 3148 Methods of test for water for making concrete
BS : 4449 Specification for hot rolled steel bars for the reinforcement of concrete
BS : 4461 Specification for cold rolled steel bars for the reinforcement of concrete
BS : 5075 Concrete Admixtures

3. Design and Construction

- BS : 639 1986 specification for covered carbon and carbon manganese steel electrode for manual metal-arc welding
BS : 1856 General requirement for the metal-arc welding of mild steel
BS : 1881 Testing Concrete
BS : 5328 Concrete
BS : 5573 Code of Practice for safety. Precautions in the construction of large diameter boreholes for piling and other purposes.
BS : 8004 Foundations
BS : 8110 Structural use of concrete

4. Machinery

- BS : 1305 Specification for Batch Type concrete mixers
BS : 3963 Method for testing the mixing performance of concrete mixers.
BS : 4251 Truck Type concrete mixers

DAILY PILE RECORD FOR LARGE-AND SMALL-DIAMETER BORED PILES
 PILE RECORDS TO BE SUBMITTED TO OFFICE DAILY
 A SEPARATE SHEET TO BE USED FOR EACH PILE

BLOCK NUMBER		DRAWING NUMBER / /				
1. General	PILE REF. NO.		PILE DIA.		LEVEL OF BASE	
			UNDERREAM DIA.			
	GROUND LEVEL		CUT OFF LEVEL		CONCRETED LEVEL	
2. Drilling	DATE STARTED		DATE COMPLETED		AIR TEMP	
	ERROR IN POSITION ON PLAN		ERROR IN PLUMB		DEPTH BORED	
3. Obstructions Natural Unnatural	TYPE		DEPTH ENCOUNTERED		PENETRATION TIME	
	TYPE		DEPTH ENCOUNTERED		PENETRATION TIME	
4. *Steel main steel links or helix	NO. OF BARS		DIAMETER		LENGTH	
	CENTRES OF BARS/PITCH		DIAMETER		COVER TO ALL STEEL	
5. Concrete	DATE STARTED		DATE COMPLETED		CONCRETE TEMP.	QUANTITY ACTUAL: THEORETICAL:
	MIX		SLUMP		SUPPLIER	
6. Borehole log and rock excavation	DEPTH OF SOIL	DESCRIPTION OF SOIL	DEPTH OF ROCK	DESCRIPTION OF ROCK	DEPTH OF ROCK AUGERED	DEPTH OF ROCK CHISELLED
7. *Casing	DEPTH OF TEMPORARY CASING		DEPTH OF PERMANENT CASING		REASON FOR USE OF PERMANENT CASING	
8. *Water	DEPTH ENCOUNTERED		DETAILS OF STRONG FLOW		DETAILS OF REMEDIAL MEASURES	
	DEPTH TO STRONG FLOW					

Note: * If there are no changes to be recorded, items 3, 4, 7 and 8 need be completed for the *first pile only* in each block.

Remarks

SIGNED

CONTRACT SITE ENGINEER

SECTION 2 - GENERAL REQUIREMENTS FOR MATERIALS

2.01 GENERAL

All materials shall be in accordance with Section 1 of this specification, Schedule 1 and this section, except where there may be conflict of requirements, in which case those in the Schedule 1 shall take precedence.

2.02 CEMENT

2.02.1 Type of cement

Cement shall be ordinary Portland, rapid hardening Portland, sulphate resisting Portland, super-sulphated or Portland blast-furnace cement unless otherwise specified. When forwarding his piling method and programme to the Engineer, the Contractor shall submit for approval the type of cement, other than ordinary Portland cement, he proposes to use. High alumina cement shall not be used.

2.02.1 Storage of cement

All cement shall be stored in separate containers according to type in substantially built waterproof stores or silos.

2.03 AGGREGATE

2.03.1 Types of aggregate

Aggregates shall consist of naturally occurring material unless otherwise specified or ordered. The Contractor shall inform the Engineer of the source of supply of the aggregates before the commencement of work and, at the request of the Engineer, provide evidence regarding their properties and consistency.

The total amount of chloride content (i.e. from aggregate, admixtures, etc.) expressed as the chloride ion percentage by mass of cement, shall not exceed 0.4%.

The use of marine aggregates will not normally be approved for use other than with ordinary or sulphate resisting Portland cement.

2.03.2 Storage of aggregates

All aggregates brought to the site shall be free and kept free from deleterious matter. Aggregates of different types and sizes shall be stored separately in different hoppers or different stockpiles.

2.04 WATER

2.04.1 Availability

If water for the works is not available from a public supply, approval shall be obtained regarding the source of water.

2.04.2 Tests

When required by the Engineer, the Contractor shall arrange for tests of the water for the works to be carried out in accordance with BS 3148 before and during the progress of the work.

2.05 ADMIXTURES

Admixtures shall be used when required, with the approval of the Engineer.

2.06 CONCRETE MIXES

2.06.1 Grade designation

Grade of concrete shall be denoted by the characteristic 28 day test cube strength in Newton per square millimetre.

2.06.2 Mix

Concrete mixes shall be Grade 25 or above of BS 5328, Part 1, Clause 5.1.

The concrete used shall have a workability as indicated in Appendix 2.1.

The concrete mix should have a water/cement ratio not exceeding 0.6.

The Contractor shall be responsible for selecting the mix proportions to achieve the required strength and workability, but the Engineer will be responsible for specifying the minimum cement content and any other properties to ensure durability.

Complete information on the mix and sources of aggregates for each grade of concrete and the water/cement ratio and the proposed degree of workability shall be approved before work commences.

2.06.3 Sulphate attack

For concrete in piles exposed to sulphate attack the requirements of Table 17 of BS 8004 shall be observed.

2.06.4 Minimum cement content

The cement content in any mix shall be not less than 300 kg/m^3 . Where concrete is to be placed under water or drilling mud by tremie, the cement content shall not be less than 380 kg/m^3 , or where the pile will be exposed to sea water 400 kg/m^3 .

2.06.5 Maximum cement content

The cement content in any mix shall not exceed 550 kg/m^3 .

2.07 TRIAL MIXES

2.07.1 General

When designed mixes are specified trial mixes shall be prepared for each grade of concrete in accordance with BS 1881, unless there are existing data showing that the proposed mix proportions and manufacture will produce a concrete of the strength and quality required having adequate workability for compaction by the method to be used in placing.

2.07.2 Preliminary trial mixes

When required in accordance with clause 2.07.1 the Contractor shall, before the commencement of concreting, have preliminary trial mixes prepared, preferably under full-scale production conditions or, if this is not possible, in an approved laboratory using a sufficient number of samples to be representative of the aggregates and cement to be used. Unless otherwise approved for each grade of concrete a set of six cubes shall be made from each of three batches in accordance with clause 3.4.3 of BS 5328, Part 3. From each set of six cubes three shall be tested at an age of 7 days and three at 28 days.

This procedure shall be followed when accelerated testing is proposed for works cubes, but an additional three cubes from each batch shall be made, cured and tested in accordance with the accelerated regime.

2.07.3 Trial mixes during the work

Where a trial mix is required after commencement of the work the procedure in clause 2.07.2 shall be adopted for full-scale production conditions as approved. The strength requirement shall be as in clause 2.07.5.

2.07.4 Workability

The workability of each batch of the trial mixes shall be determined by the slump test as described in BS 1881 or by an alternative approved method.

2.07.5 Standard of acceptance

Unless otherwise approved, the trial mix proportions will be approved if the criteria in clause 3.4.3 of BS 5328, Part 3 are met, in particular that the average 28 day compressive strength of 3 cubes exceed the specified characteristic strength by at least 10 N/mm².

2.07.6 Variations in approved mix

When a mix has been approved, no variations shall be made in the proportions, the original source of the cement and aggregates or their type, size or grading zone without the consent of the Engineer. Further tests may be required.

2.08. STEEL REINFORCEMENT

2.08.1 Condition

Steel reinforcement shall be stored in clean conditions. It shall be clean, and free from loose rust and loose mill scale at the time of fixing in position and subsequent concreting.

2.08.2 Grade

The grade of steel shall be as specified.

2.08.3 Joints

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

2.09 DRILLING FLUID

Bentonite, as supplied to the site and prior to mixing, shall be in accordance with specification DFCP 4 of the Oil Companies Materials Association, London.

A certificate shall be obtained by the Contractor from the manufacturer of the bentonite powder showing the properties of each 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 centipoise) and the gel strength (in N/m^2) for solids in water.

The requirements for mixing and testing of bentonite are given in Appendix 2.2.

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Appendix 2.1

STANDARDS FOR WORKABILITY OF CONCRETE

Piling mix Workability	Slump (mm)		Typical conditions of use
	Minimum	Maximum	
A	75	125	Placed into water-free unlined bore-widely spaced reinforcement leaving ample room for free movement between bars
B	100	175	Where reinforcement is not spaced widely enough to give free movement between bars. Where casting level is within the casing. Where pile diameter is less than 600 mm
C	150		Where concrete is to be placed by tremie under water or drilling fluid.

Appendix 2.2

REQUIREMENTS FOR MIXING AND TESTING OF BENTONITE

A2.2.1 Mixing

Bentonite shall be mixed thoroughly with clean fresh water to make a suspension which will 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 suspension or prehydrate the bentonite in fresh water so as to render it suitable in all respects for the construction of piles.

A2.2.2 Tests

The frequency of testing drilling fluid and the method and procedure of sampling shall be proposed by the Contractor prior to the commencement of the work. The frequency may subsequently be varied, depending on the consistency of the results obtained.

Control tests shall be carried out on the bentonite suspension using suitable apparatus. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed.

Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite supplied to the pile boring. For average soil conditions the results shall generally be within the ranges stated in Table A2.1.1. The tests shall be carried out until a consistent working pattern has been established, account being taken of the mixing process, any blending of freshly mixed bentonite suspension and previously used bentonite suspension and any process which may be used to remove impurities from previously used bentonite suspension. When the results show consistent behaviour, the tests for shear strength and pH value may be discontinued, and tests to determine density and viscosity shall be carried out as agreed with the Engineer. In the event of a change in the established working pattern, tests for shear strength and pH value shall be reintroduced for a period if required.

Table A2.1.1

Property to be measured	Range of results at 20°C	Test method
Density	Less than 1.10 g/ml	Mud density balance
Viscosity	30 - 90 s or	Marsh cone method
	Less than 20 cp	Fann viscometer*
Shear strength (10 minute gel strength)	1.4 - 10 N/m ² or	Shearometer
	4-40 N/m ²	Fann Viscometer
pH	9.5 - 12	pH indicator paper strips or electrical pH meter

* where the Fann Viscometer is specified, the fluid sample should be screened by a No. 52 sieve (300 μm) prior to testing.

SECTION 3 - GENERAL REQUIREMENTS OF WORKMANSHIP

3.01 GENERAL

All work shall be in accordance with Section 1 of this specification, Schedule 1 and this section, except where there may be conflict of requirements, in which case those in Schedule 1 shall take precedence.

3.02 SETTING OUT

The Contractor shall check the casing position for each pile during and immediately after placing the casing. The tolerances should be in accordance with Clause 1.06.

3.03 DIAMETER OF PILES

The diameter of a pile shall be not less than the specified diameter indicated in Schedule 1.

3.04 BORING

3.04.1 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 that a flow of concrete could be induced from or damage caused to any of the piles. A minimum period of 3 days shall be provided before boring near recently cast piles, unless otherwise agreed with the Engineer.

3.04.2 Temporary casings

- (i) Temporary casing of approved quality or an approved alternative method shall be used to maintain the stability of the pile excavation which might otherwise collapse.
- (ii) 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.
- (iii) The Contractor's equipment should be capable of sinking steel casing to support the full length of borehole, if so directed by the Engineer.

3.04.3 Stability of pile excavation using drilling fluid

- (i) Where the use of drilling fluid is approved for maintaining the stability of a boring, the level of the fluid in the excavation shall be maintained so that the fluid pressure always exceeds the pressures exerted by the soil and external groundwater.
- (ii) The fluid level shall be maintained at a level not less than 1 m above the level of the external groundwater.
- (iii) An adequate temporary casing shall be used in conjunction with the method to ensure stability of the strata near ground level until concrete has been placed. A minimum length of casing of 1.5m shall be used.
- (iv) In the event of a rapid loss of drilling fluid 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.

3.04.4 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. Any disposal of drilling fluid shall comply with the regulations of the local controlling authority.

3.04.5 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.

3.04.6 Continuity of Construction

A pile constructed in a stable cohesive soil without the use of temporary casing or other form of support shall be bored and concreted without delay.

3.04.7 Enlarged pile bases

An enlarged base mechanically formed shall be not smaller than the dimensions specified and shall be concentric with the pile shaft to within a tolerance of 10% of the pile diameter. The sloping surface of the frustrum forming the enlargement shall make an angle to the horizontal of not less than 55°.

3.04.8 Cleanliness of pile bases

On completion of boring, loose, disturbed or remoulded soil shall be removed from the base of the pile to the satisfaction of the Engineer.

3.04.9 Inspection

Each pile boring shall be approved by the Engineer or his representative on site prior to the placing of concrete in it.

The Contractor shall provide all facilities and assistance to enable the Engineer or his representative to carry out inspection.

3.04.10 Protection of borehole

All boreholes must be protected from the possibility of any surface water entering the borehole from time to time and until the borehole is completed and ready to be concreted, as well as during the concreting operation. No concreting will be allowed to commence until the borehole has been inspected and the said precaution taken.

3.05 REINFORCEMENT

3.05.1 Bending of reinforcement

No heating of reinforcement bars shall be permitted for bending of the bars without the consent of the Engineer.

3.05.2 Placing of reinforcement

All intersecting bars shall be tied together with approved wire unless otherwise permitted by the Engineer.

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 placed and maintained in position.

The cover to all reinforcement shall be not less than 50 mm. The distribution and spacing of spacer blocks shall be approved, and these should be consistent with their purpose. The spacer blocks shall be made with 10 mm maximum aggregate size and shall have a strength not less than that of the concrete in the pile.

The borehole shall not be damaged during placement of reinforcement cage in the borehole.

3.05.3 Welding of reinforcement

Welded joints and welding procedures shall be carried out in accordance with BS 639 or BS 1856.

3.06**MIXING CONCRETE****3.06.1****Type of mixer**

The mixer shall be of the batch type, unless otherwise approved, and shall have either been manufactured in accordance with BS 1305 or shown by tests in accordance with BS 3963 to have mixing performance within the limits of Table 6 of BS 1305.

3.06.2**Tolerance of mixer blades**

The mixing blades of pan mixers shall be maintained within the tolerances specified by the manufacturers of the mixers, and the blades shall be replaced when it is no longer possible to maintain the tolerance by adjustment.

3.06.3**Cleaning of mixers**

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before another batch of concrete is mixed. Unless otherwise specified by the Engineer, the first batch of concrete through mixer shall contain the normal batch quantity of cement and sand, but only two thirds of the normal quantity of coarse aggregate. Mixing plant shall be thoroughly cleaned between the mixing of different types of cement.

3.06.4**Maximum and Minimum temperatures**

The measured concrete temperature shall not exceed any specified maximum value or fall below any specified minimum value.

3.07**TRANSPORTING CONCRETE****3.07.1****Transportation of concrete**

The method of transporting concrete shall be submitted for approval. Concrete shall be transported in uncontaminated watertight containers in such a manner that loss of material and segregation are prevented.

Discharge of the concrete shall be completed within 1 1/2 hrs, or before the drum has revolved 300 revolutions, or before proper placement and compaction of the concrete can no longer be accomplished, whichever comes first, after the introduction of mixing water to cement and aggregates, or the introduction of the cement to the aggregates. These limitations may be waived by the Engineer if the concrete is of such slump after the 1 1/2 hr time or 300 revolution limit has been reached that it can be placed, without the addition of water to the batch. In hot weather, or under conditions contributing to quick stiffening of the concrete, a time less than 1 1/2 hrs may be specified by the Engineer.

3.07.2 Pumping of concrete

The use of pumped concrete and the methods employed in its use shall be subject to approval.

3.08 READY-MIXED CONCRETE

3.08.1 Conditions for use

Subject to approval the Contractor may use ready mixed concrete in accordance with BS 5328 or the relevant SLS Standard. Approval shall be obtained for each proposed use of ready-mixed concrete in different sections of the Works and for each different mix, which shall comply with this specification.

3.08.2 Mixing plant

Unless otherwise agreed by the Engineer, truck mixer units and their mixing and discharge performance shall comply with the requirements of BS 4251.

3.09 BATCHING CONCRETE

3.09.1 General

Unless otherwise specified the requirements in clauses 3.09.2, 3.09.3 and 3.09.4 shall be met.

3.09.2 Accuracy of weighing and measuring equipment

The weighing and water-dispensing mechanisms shall be maintained at all times to within the limits of accuracy described in BS 1305.

3.09.3 Tolerance in weights

The weights of the quantities of each size of aggregate and of cement shall be within a tolerance of 2% of the respective weights per batch after due allowance has been made for the presence of free water in the aggregates which shall be determined by the Contractor by an approved method.

3.09.4 Moisture content of aggregates

The moisture content of aggregates shall be measured immediately before mixing and as frequently thereafter as is necessary to maintain consistency of mix.

3.10 PLACING CONCRETE

3.10.1 General

- (i) 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.
- (ii) The concrete shall be placed without such interruption as would allow the previously placed batch to have hardened. The method of placing should be approved by the Engineer.
- (iii) 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.

3.10.2 Workability of concrete

Slump measured at the time of discharge into the pile boring shall be in accordance with the standards shown in Appendix 2.1.

Concrete shall be of the workability approved under Clause 2.06.2 when in its final position and after all constructional procedure in forming the pile have been completed.

3.10.3 Compaction

Internal vibrators shall not be used to compact concrete unless the Contractor is satisfied that they will not cause segregation or arching of the concrete, and unless the method of use has been approved.

3.10.4 Placing concrete in dry boring

Approved measures shall be taken to avoid segregation and bleeding and to ensure that the concrete at the bottom of the pile is not deficient in grout.

3.10.5 Placing concrete under water or drilling fluid

- (i) Concrete to be placed under water or drilling fluid shall be placed by tremie unless otherwise approved and shall not be discharged freely into the water or drilling fluid.
- (ii) Before placing concrete, measures shall be taken to ensure that there is no accumulation of silt or other material at the base of the boring, and the Contractor

shall ensure that heavily contaminated drilling fluid, which could impair the free flow of concrete from the pipe of the tremie has not accumulated at the bottom of the hole.

A sample of the drilling fluid 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 or replace the drilling fluid as approved to meet the specifications.

- (iii) The concrete shall be a rich coherent mix of high workability in accordance with Clause 2.06.4 and Mix C of Appendix 2.1.
- (iv) The concrete shall be placed in such a manner that segregation does not occur.
- (v) During and after concreting care shall be taken to avoid damage to the concrete from pumping and de-watering operations.
- (vi) 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. 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.
- (vii) The internal diameter of the pipe of the tremie shall be not less than 150 mm for concrete made with 20 mm aggregates, and not less than 200 mm for concrete made with 40 mm aggregate. It shall be so designed that external projections are minimized 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.
- (viii) Concreting shall be carried out continuously in one operation.

3.11 TESTING WORKS CONCRETE

3.11.1 Sampling

Concrete for the piles shall be sampled in accordance with BS 1881.

3.11.2 Workability

The workability of concrete shall be determined by the slump test as described in BS 1881 or by an alternative approved method. The workability shall be measured on each truck load of concrete.

3.11.3 Works cube tests

For each grade of concrete four cubes shall be made from a single batch when required for each 50 m³ of concrete or part thereof in each pile. The cubes shall be made, cured and tested in accordance with BS 1881 or as otherwise approved. One shall be tested at an age of 7 days and the other three at 28 days. Alternatively cubes may be tested in accordance with an approved accelerated testing regime. The Contractor shall submit original certificates of the results of all tests to the Engineer.

3.11.4 Standard of acceptance

The concrete shall be deemed to comply with the specified characteristic strength if the following are all satisfied for the 3 cubes tested at an age of 28 days:

- (a) The average value of 3 cubes made from the same sample shall exceed the characteristic strength by an amount as specified in Schedule 1.
- (b) The lowest individual strength of any cube shall not be lower than the characteristic strength; and
- (c) The allowable range (maximum minus minimum value) of the strength of the 3 cubes made from the same sample shall not exceed 20 percent of the average value from the 3 cubes.

3.11.5 Records of tests

The Contractor shall keep a detail record of the results of all tests on concrete and concrete materials. Each test shall be clearly identified with the piles to which it relates.

3.12 EXTRACTION OF CASING

3.12.1 Workability of Concrete

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

3.12.2 Concrete level

- (i) 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 or contaminated.
- (ii) No concrete shall be placed in the boring once the bottom of the casing has been lifted above the top of the concrete. The concrete shall be placed continuously as the casing is extracted until the desired head of concrete is obtained.

- (iii) 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.

3.12.3 Vibrating Extractors

The use of vibrating casing extractors will be permitted subject to Clauses 1.13.1 and 1.13.2.

3.12.4 Water levels

In the event of the groundwater level being higher than the required pile head casting level shown on the Drawings, the Contractor shall submit his proposals for approval by the Engineer prior to placing concrete. The pile head shall not be left below groundwater level unless approved precautions are taken.

3.13 TEMPORARY BACKFILLING ABOVE PILE CASTING LEVEL

After each pile has been cast any empty bore remaining shall be protected and shall be carefully backfilled as soon as possible with approved materials.

3.14 FINISHING PILE HEAD

- (i) Where a temporary casing is used, the top of the piles should be brought up sufficiently far above the required finished level to allow for slumping on withdrawal of the casing and to permit all laitance and weak concrete to be removed. The casting tolerance above cut-off level (in m) is as given below.
- (a) For piles cast in dry boreholes using temporary casing and without the use of permanent lining
$$= 0.3 + (H/12) + (C/8)$$
- (b) For piles cast in dry boreholes within permanent lining tubes or permanent casings
$$= 0.3 + (H/10)$$
- (c) For piles cast under water or drilling fluid
$$= 1.0 + (H/12) + (C/8)$$

where H = cut off distance (in m) below commencing surface;

and C = length of temporary casing (in m) below the commencing surface.

- (ii) The tops of piles should be protected during general excavations. The final excavation next to the piles should be undertaken by hand.
- (iii) Any defective concrete in the head of the completed pile should be cut off and made good with concrete well bonded to the old. The reinforcement in the pile should be carefully exposed for a sufficient distance corresponding to the anchorage bond length to permit it to be adequately anchored to the pile cap.

SECTION 4 - SPECIAL REQUIREMENTS FOR PILES FOUNDED ON ROCK

4.01 DEFINITIONS

Hard bed rock level will be as defined in Schedule 1.

4.02 ADDITIONAL INVESTIGATIONS

Before undertaking any piling work, the Contractor shall ensure that a sufficient number of boreholes is available to establish the rock profile at the site.

The Contractor shall submit to the Engineer for his approval the additional number of such boreholes he considers essential to supplement the information already available in the Soil Investigation Reports indicated in Clause 1.05.1. The cost of such investigation shall be included in the tender, as a Supplementary Item.

4.03 FOUNDING PILES ON HARD BED ROCK

4.03.1 Depth to hard rock

The Contractor shall submit to the Engineer for his concurrence,

- (i) the depth to hard bed rock anticipated from which rock socketing will commence.
- (ii) the method of identification of hard bed rock level during his piling operations,
- (iii) an estimate for the allowable carrying capacity of a pile based on rock properties, and the basis for his estimation.

4.03.2 Rock Socket

Unless otherwise approved, piles shall be taken to a minimum of 300 mm into hard bed rock where the surface of the bed rock is not very steep.

Where the rock is steeply sloping, the rock socket should be of such a length that the entire cross section for the pile is end bearing on hard bed rock.

4.04 FOUNDING PILES ON WEATHERED ROCK

4.04.1 General

When the Site Investigation Report shows that

- (i) the depth to hard bed rock is very large, and
- (ii) a deep zone of weathered rock exists;

Consideration may be given to the termination of the piles on weathered rock.

4.04.2 Depth of Termination of piles

The Contractor shall submit to the Engineer for his concurrence

- (i) the depth at which a pile will be terminated
- (ii) the method of identification he proposes to use for identifying the level at which the pile will be terminated.
- (iii) an estimate for the allowable carrying capacity of a pile based on geotechnical properties, and the basis for his estimation.

4.05 ULTIMATE RESPONSIBILITY FOR FOUNDING DEPTHS

The Contractor shall be ultimately responsible to ensure that the piles have been taken to the required founding depths and installed in accordance with Clauses 1.08 and 1.10 so as to carry the design working loads.

SECTION 5 - PILE TESTING BY MAINTAINED LOAD TEST

5.1 GENERAL

This Section deals with the testing of a pile by the application of an axial load in which each increment of load is held constant either for a defined period of time or until the rate of movement fall to a specified value.

5.2 DEFINITIONS

- Allowable Load :** The load which may be safely applied to a pile after taking into account its ultimate bearing capacity, allowable settlement, negative friction, and pile spacing.
- Compression Pile:** A pile which is designed to resist an axial force such as would cause it to penetrate further into the ground.
- Kentledge :** The dead weight used in a loading test
- Preliminary Pile:** A pile installed before the commencement of the main piling works for the purpose of establishing the suitability of the chosen type of pile and for confirmation of its design, dimensions and bearing capacity.
- Proof Load :** A load applied to a selected working pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed 150% of the working load on a pile.
- Reaction System:** The arrangement of kentledge, piles or anchors that provides a resistance against which the pile is tested.
- Tension Pile :** A pile which is designed to resist an axial force such as would cause it to be extracted from the ground.
- Test Pile:** Any pile to which a test is, or is to be applied.
- Working Load:** The load which the pile is designed to carry.
- Working Pile :** One of the piles forming the foundation of a structure.

5.3 DESCRIPTION OF WORKS

The number of preliminary piles that shall be loaded upto 200% of working load or upto failure (whichever is less) is specified in Schedule 1.

The number of working piles that shall be loaded upto 150% of working load or upto failure (whichever is less) is specified in Schedule 1.

5.4 SUPERVISION:

All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure.

5.5 SAFETY PRECAUTIONS

5.5.1 General

When preparing for, conducting and dismantling a pile test, the Contractor shall carry out such measures as are necessary for the provision and maintenance of safe working conditions.

5.5.2 Kentledge

Where kentledge is used, the Contractor shall construct the foundations for the kentledge and any cribwork, beams or other supporting structure in such a manner that there will be no differential settlement, bending or deflection of an amount that constitutes a hazard to safety or impairs the efficiency of the operation.

The kentledge shall be adequately tied or held together to prevent it falling apart, or becoming unstable because of the deflection of the supports.

The weight of the kentledge shall be greater than the maximum test load.

5.5.3 Tension piles and Ground anchors

Where tension piles or ground anchors are used, the Contractor shall ensure that the load is correctly transmitted to all the tie rods or bolts. The extension of rods by welding shall not be permitted.

5.5.4 Testing Equipment

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head, the whole system will be stable upto the maximum load to be applied.

Means shall be provided to enable dial gauges to be read from a position clear of the kentledge stack or test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulics pressure, and so on might constitute a hazard to personnel.

The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum working pressure without leaking.

5.6 PREPARATION OF A WORKING PILE TO BE TESTED

5.6.1 Cut-off level

The pile shaft shall terminate at the normal cut-off level or at a level required by the Engineer.

If the cut-off level is below ground level, two methods for preparation of working pile can be adopted.

Method 1 - Extend the pile shaft above the cut off level.

If the extension of the shaft influences the load bearing capacity of the pile, a sleeve shall be installed and kept in place during testing to eliminate friction which would not arise in the Working Pile.

Method 2 - The shaft is not extended.

In this method the soil around the Working Pile is excavated upto cut-off level. The excavation is carried out in a sufficiently large area so as to be able to set up the test equipment for carrying out the Pile Load Test.

5.6.2 Pile Head

The pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile. It should be sufficiently large to accommodate the loading and settlement measuring equipment, and adequately reinforced or protected to prevent damage from the concentrated

application of load from the loading equipment.

The pile cap shall be concentric with the test pile. The joint between the cap and the pile shall have a strength equivalent to that of the pile.

Sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that, at the maximum expected settlement, load is not transmitted to the ground except through the pile.

5.7 CONCRETE TEST CUBES

Test cubes shall be cast from the concrete used in

- (i) building up a Working Pile;
- (ii) casting of concrete cap, if this is separate from the concrete used in (i) above.

The cubes shall be made and tested in accordance with the standards given in Appendix 1.1.

The pile test shall not be started until the strength of the cubes exceeds the 28 day strength in any pile section.

5.8 REACTION SYSTEMS

5.8.1 Compression Tests

Compression tests shall be carried out using kentledge, tension piles or specially constructed anchorages.

5.8.2 Working piles

Working piles shall not be used as reaction piles without approval.

5.8.3 Spacing

Where kentledge is used, the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall not be less than 1.3 m.

The centre to centre spacing of vertical reaction piles, including working piles used as reaction piles, from a test pile shall be not less than 3 times the diameter of the test pile or the reaction piles or 2 m, whichever is the greatest.

Where ground anchors are used to provide a test reaction for loading in compression, no part of the anchor transferring load to the ground shall be closer to the test pile than 3 times the diameter of the test pile.

5.8.4 Loading arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out.

5.9 EQUIPMENT FOR APPLYING LOAD

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The total capacity of the jacks shall be at least equal to the required maximum load. The jack or jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile.

5.10 MEASUREMENT OF LOAD

The load shall be measured by a load measuring device and by a calibrated pressure gauge included in the hydraulic system. Readings of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data the values given by the load measuring device shall normally be used; the pressure gauge readings are required as a check for gross error.

The load measuring device may consist of a proving ring, load measuring column, pressure cell or other appropriate system. A spherical seating shall be used in conjunction with any devices that are sensitive to eccentric loading; care must be taken to avoid any risk of buckling. Load measuring devices and jacks shall be short in axial length in order to achieve the best possible stability; the Contractor shall pay attention to details in order to ensure that axial loading is maintained.

The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. The pressure gauge and hydraulic jack shall be calibrated together. Certificates of calibration shall be supplied to the Engineer.

The Engineer's agreement shall be obtained in writing before any modification of this procedure is adopted.

5.11 ADJUSTABILITY OF LOADING EQUIPMENT

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of a maintained loading test.

5.12 MEASURING MOVEMENT OF PILE HEADS

The movement of the pile head shall be measured by one of the methods in clauses 5.12.1, 5.12.2, 5.12.3 and 5.12.4.

5.12.1 Levelling methods

An optical or any other levelling method by reference to an external datum may be used.

Where a level and staff are used, the level and scale of the staff shall be chosen to enable readings to be made to within an accuracy of 0.5 mm. A scale attached to the pile or pile cap may be used instead of a levelling staff. At least two datum points shall be established on permanent objects or other well founded structures or deep datum points shall be installed. Each datum point shall be situated so that only one setting up of the level is needed.

No datum point shall be affected by the test loading or other operations on the site.

Where another method of levelling is proposed this shall be approved in writing.

5.12.2 Independent reference frame

An independent reference frame may be set up to permit measurement of the movement of the pile. The supports for the frame shall be founded in such a manner and at such a distance from the test pile, kentledge support cribs, reaction piles, and anchorage that movements of the ground in the vicinity of the equipment do not cause movement of the reference frame during the test which will affect the required accuracy of the test. Check observations of any movement of the reference frame shall be made and a check shall be made of the movement of the pile head relative to an external datum during the progress of the test. In no case shall the supports be less than three test pile diameters or 2m, whichever is the greater, from the centre of the test pile.

The measurement of pile movement shall be made by two dial gauges rigidly mounted on the reference frame that bear on surfaces normal to the pile axis fixed to the pile cap or head. Alternatively the gauges may be fixed to the pile and bear on surfaces on the reference frame. The dial gauges shall be placed in diametrically opposed positions and be equidistant from the pile axis. (The use of 3 dial gauges placed equidistant from the pile axis shall also be allowed.) The dial gauges shall enable readings to be made to within an accuracy of 0.01 mm, and should have a stem travel of at least 25 mm.

The reference frame shall be protected from sun and wind.

5.12.3 Reference wire

A reference wire shall be held under constant tension between two foundations formed as in the method in clause 5.12.2. The wire shall be positioned against a scale fixed to the pile and the movement of the scale relative to the wire shall be determined.

Check observations of any movements of the supports of the wire shall be made or a check shall be made of the movement of the pile head as in the method in clause 5.12.1. Readings shall be taken to within an accuracy of 0.5 mm.

The reference wire shall be protected from sun and wind.

5.12.4 Other methods

The Contractor may submit any other method for measuring the movement of pile head for approval.

5.13 PROTECTION OF TESTING EQUIPMENT

5.13.1 Protection from weather

Throughout the test period all equipment for measuring load and movement shall be protected from the weather.

5.13.2 Prevention of disturbance

Construction equipment and persons who are not involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measurement apparatus.

5.14 SUPERVISION

5.14.1 Notice of test

The Contractor shall give the Engineer at least 24 hours' notice of the commencement of the test.

5.14.2 Records

During the progress of a test, the testing equipment and all records of the test as required in clause 5.16.2 shall be available for inspection by the Engineer.

5.15 TEST PROCEDURE

5.15.1 Proof test by maintained load test

The maximum load which shall be applied in a proof test on a working pile is 1.5 times the working load. The loading and unloading shall be carried out in stages as shown in Table 5.1.

Following each application of an increment of load the load shall be held for not less than the period shown in Table 5.1 or until the rate of settlement is less than 0.25 mm/h and slowing down. The rate of settlement shall be calculated from the slope of the curve

obtained by plotting values of settlement versus time and drawing a smooth curve through the points.

Each stage of unloading shall proceed after the expiry of the period shown in Table 5.1.

For any period when the load is constant, time and settlement shall be recorded immediately on reaching the load and at approximately 15 min intervals for 1 h, at 30 min intervals between 1 h and 4 h, and at 1 h intervals between 4 h and 12 h after the application of the increment of load.

Table 5.1

Load, percentage of working load	Minimum time of holding load
25	1 h
50	1 h
75	1 h
100	1 h
75	10 min
50	10 min
25	10 min
0	1 h
100	6 h
125	1 h
150	6 h
125	10 min
100	10 min
75	10 min
50	10 min
25	10 min
0	1 h

5.16 PRESENTATION OF RESULTS

5.16.1 Results to be submitted

Results shall be submitted as

- (a) a summary in writing to the Engineer, unless otherwise directed, within 24 hours of the completion of the test, which shall give for a proof test by maintained load for each stage of loading, the period for which the load was held, the load and the maximum settlement recorded.
- (b) the completed schedule of recorded data as the clause 5.16.2 within seven days of the completion of the test.

5.16.2 Schedule of recorded data

The Contractor shall provide information about the tested pile in accordance with the following schedule where applicable.

(a) General

Site location
Contract identification
Proposed structure
Main Contractor
Piling Contractor
Engineer
Client
Date of test

(b) Pile details

Identification (number and location)
Position relative to adjacent piles
Brief description of location
Ground level at pile position
Head level at which test load is applied
Shape and size of cross section of pile, position of change in cross section
Head details
Length in ground
Level of toe
Any permanent casing
Concrete mix
Aggregate type and source
Cement type
Slump
Cube test results for pile and cap
Reinforcement

(c) Installation details

Dates and times of boring and concreting of test pile and adjacent piles
Unexpected circumstances and difficulties
Date and time of casting concrete pile cap
Start and finish of each operation during installation of a pile and subsequent testing
Delays due to weather conditions
Type of equipment used and method of boring
Temporary casing, method of installation and extraction
Strata encountered during boring
Water encountered during boring
Method of placing concrete and conditions pertaining

Volume of concrete placed
Concrete level before and after extraction of casing.

(d) Test procedure

Weight of kentledge
Tension pile, ground anchor or compression pile details
Plan of test arrangement showing position and distances of kentledge supports, rafts, tension or compression piles and reference frame to test pile
Jack capacity
Method of load measurement
Method(s) of settlement measurement
Relevant dates and times

(e) Test Results

In tabular form
In graphical form: load plotted against settlement, load plotted against uplift, with times
Ground heave
Effect on adjacent structure

(f) Site investigation

Site investigation report number
Borehole references

5.17 COMPLETION OF A TEST

5.17.1 Measuring equipment

On completion of a test all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in further tests or removed from the Site as specified.

5.17.2 Kentledge

Kentledge and its supporting structure shall be removed from the test pile and stored so that they are available for use in further tests or removed from the site as specified.

5.17.3 Ground anchors and temporary piles

On completion of a preliminary test, tension piles and ground anchors shall be cut off below ground level, removed from the site and the ground made good with approved material as specified.

5.17.4 Preliminary test pile cap

The pile cap, if formed in concrete, shall be broken off and the resulting material disposed of off the site. If the pile cap is made of steel it shall be cut off and stored so that it is available for use in further tests or removed from the site as specified.

The pile head shall be made good or extended to the cut off level in clause 5.6.1

5.17.5 Proof test pile cap

On completion of a test on a proof pile, the test pile cap, if in concrete, shall be stripped and left in a state ready for incorporation in the Permanent Works and the resulting material disposed of off the site.

If the pile cap is made of steel it shall be cut off and stored so that it is available for use in further tests or removed from the site as specified.

SCHEDULES

Specifications The specifications shall be "Specifications for bored and cast in situ reinforced concrete piles" published by ICTAD, with information, performance specification, amendments and additions as described in the schedules.

- Schedule 1 : Information
- Schedule 2 : Performance Specification
- Schedule 3 : Specification Amendments
- Schedule 4 : Specification Additions

Schedule 1 : Information

S1.1 Name of Contract

(Note. A concise and unique name is required for contract and reporting purposes. The name should include the nearest town.)

S1.2 General Information regarding project

- (a) Site location
- (b) Proposed structure
- (c) Name of client
- (d) Name of Engineer/Consultants.

S1.3 Site Investigation Document

S1.4 Construction Drawings (for Engineer designed pile foundations)

This should include

- (i) Pile layout
- (ii) For each pile,
 - Ref. No.
 - Location
 - Pile Type
 - Nominal diameter
 - Cut - off level
 - Base level
 - Length, diameter, and other details of reinforcement
 - Working load

S1.5 Concrete mix details

- (a) Concrete grade (*)
- (b) Maximum size of aggregate (*)
- (c) Minimum cement content
- (d) Maximum and minimum temperatures during placement
- (e) When testing works concrete as per Clause 3.11, the average 28 day Strength of 3 cubes made from the same sample shall exceed the characteristic strength by an amountN/mm².

(* Note These may be omitted for Contractor designed pile foundations.)

S1.6 Reinforcement details

- (a) Grade of steel (*)
- (b) Length, diameter, and other details of reinforcement. (*)

(* Note These may be omitted for Contractor designed pile foundations.)

S1.7 Definition of hard bed rock level

Hard bed rock level will be defined as the rock level at which a core recovery of more than 75% can be obtained.

* S1.8 Pile Load Test details

- (a) Number of piles to be tested
- (b) Maximum test load to be applied.

Schedule 2: Performance specification

S2.1 For Maintained Pile Load Test

For load cycle upto 1.0 times Working Load,

maximum allowable gross settlement = 12 mm
maximum allowable net settlement = 6 mm

For load cycle upto 1.5 times Working Load,

maximum allowable gross settlement = 25 mm
maximum allowable net settlement = 12 mm

S.2.2 For Contractor designed pile foundations

Information shall be provided on

- (i) Column/wall layout at foundation level.
- (ii) Service Loads on Columns/walls at foundation level.
- (iii) Expected cut-off level of piles.

Schedule 3 : Specification Amendments

The following clauses are amended:

Schedule 4: Specification Additions

The following clauses are added to the specifications: