GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 8
PILING WORKS
SECTION 8

PILING WORKS

GENERAL

General requirements 8.01 The works and materials specified in Clauses 8.02 to 8.09 shall comply with the Sections stated, unless otherwise stated in this Section. In accordance with Clauses 1.11 and 1.12 of Section 1, the Contractor shall employ on the Site in connection with execution of the piling works a Construction Engineer and a Construction Supervisor who shall be full time on site to supervise the piling works.

Earthworks 8.02 Earthworks shall comply with Section 6.

Reinforcement 8.03 Steel reinforcement shall comply with Section 15.

Concrete 8.04 Concrete shall comply with Section 16.

Materials for grout 8.05 Materials for grout for piling works shall comply with Section 16.

Grouting 8.06 Grouting for piling works shall comply with Section 17.

Prestressing 8.07 Prestressing shall comply with Section 17.

Steelwork 8.08 Steelwork shall comply with Section 18.

Marine works 8.09 Marine works shall comply with Section 21.

Code of practice for piling works 8.10 Piling works shall comply with the BS 8004, except as stated in this Section.

Safety of piling works 8.11 Reference shall be made to the following documents regarding matters relating to the safety of piling works:

Code of Practice for Foundations : BS 8004

Code of Practice for Safety Precautions in the Construction of Large Diameter Boreholes for Piling and Other Purposes : BS 5573

Section 7 of ´Guidance Notes on Hand-Dug Caissons' Hong Kong Institution of Engineers, 1981

GLOSSARY OF TERMS

Hand-dug caisson 8.12 A hand-dug caisson is a pile shaft which is excavated manually and which is unlined, or lined with a ring wall following each incremental advance of the excavation, or partly unlined and partly lined.
Barrette 8.13 A barrette is a pile that is excavated using grabs and chisels through a thixotropic suspension of bentonite or other agent which supports the sides of the shaft as excavation proceeds, and which is concreted in one continuous operation.

Large-diameter bored piles and socketted steel H-piles 8.14 (1) A large-diameter bored pile is a bored pile, the diameter of which is determined by the Contract Drawings and/or proposed by the Contractor to the Engineer’s approval. It is usually formed by machine boring, grabbing or chiselling and subsequently filling the hole with concrete.

(2) Socketted steel H-piles are piles formed by inserting steel H-piles in pre-bored holes sunk into Grade III or better rock, and subsequently filling the holes with cement grout.

Minipile 8.15 A minipile is a pile with a diameter of less than 250 mm in which the load-bearing element consists of a steel tube or one or more steel reinforcement bars.

Founding rock 8.16 "Founding rock" includes "founding rock or stratum" if the pile does not reach rock level, and "concrete/rock interface" shall be construed accordingly.

MATERIALS

Steel piles 8.17 (1) Steel bearing piles and steel sheet piles shall comply with BS 5950: Part 2.

(2) Steel sheet piles shall be of a proprietary section approved by the Engineer.

Pile shoes 8.18 (1) Cast iron pile shoes for precast concrete piles shall be manufactured from chill hardened iron as used for making grey iron castings complying with BS 1452, Grade 150. The chilled iron point of the shoe shall be free of major blow-holes and other surface defects.

(2) Steel pile shoes for precast concrete piles shall be manufactured from steel complying with BS 4360, Grade 43A.

(3) Cast steel pile shoes for precast concrete piles shall be manufactured from steel complying with BS 3100, Grade A.

(4) Straps and fastenings for cast pile shoes for precast concrete piles shall be manufactured from steel complying with BS 4360, Grade 43A and shall be cast into the point of the shoe to form an integral part of the shoe.

(5) Pile shoes for driven cast-in-place piles shall be manufactured from durable materials approved by the Engineer and capable of withstanding driving stresses without damage. The shoes shall be designed to provide a watertight joint with permanent casings.

(6) Cast steel pile shoes for steel bearing piles shall be manufactured from steel complying with BS 3100, Grade A.

(7) Welded fabricated pile shoes for steel bearing piles shall be manufactured from steel complying with BS 4360, Grade 43A.
**Epoxy paint**

8.19 Epoxy based paint for epoxy coatings to steel piles shall be a proprietary type approved by the Engineer.

**Bituminous coating material**

8.20 Bituminous coating material for steel piles shall be hot-applied filled or unfilled bituminous material complying with BS 4147.

**Grout for piling works**

8.21 (1) Grout for piling works shall consist of Portand cement (PC) and water. Sand, PFA and admixtures may be used with the approval of the Engineer.

(2) The minimum cementitious content of grout shall be 600 kg/m$^3$, unless otherwise permitted by the Engineer.

(3) Grout used to fill core holes shall have a minimum crushing strength of not less than the specified grade strength of the concrete surrounding the core hole.

(4) Grout used in minipiles shall have a minimum crushing strength of 30 MPa at 28 days.

(5) The amount of bleeding of grout shall not exceed 2% in the first 3 hours and shall not exceed 4% in total. The water shall be reabsorbed by the grout during the 24 hours after mixing.

(6) Free expansion of grout shall not exceed 10% at the ambient temperature.

(7) The chloride ion content of admixtures for concrete containing embedded metal or for concrete made with SRPC shall not exceed 2% by mass of the admixture or 0.03% by mass of the cementitious content, whichever is less.

(8) The maximum total chloride content of grout, expressed as a percentage relationship between the chloride ion and the cementitious content by mass in the grout, shall not exceed 0.1%.

**Reinforcement connectors**

8.22 Reinforcement connectors for minipiles shall be capable of transmitting the total pile load in tension or compression as appropriate.

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**SURFACE TREATMENT OF STEEL PILES**

**Surface treatment of steel piles**

8.23 (1) Surface preparation and application of protective coatings other than bituminous coatings to steel piles shall be carried out in a fully enclosed well-ventilated workshop.

(2) The method of application of protective coatings to steel piles, the ambient temperature and humidity at the time of application and the time interval between the application of successive coats shall be in accordance with the manufacturer's recommendations. The complete coating shall be applied in and around clutches.

**Surface preparation of steel piles**

8.24 The surfaces of steel piles to which protective coatings will be applied shall be prepared by blast cleaning to second quality of surface finish in accordance with BS 4232 or Sa 2½ in accordance with SIS 05 59 00.
**Epoxy coatings to steel piles**

8.25  
(1) Epoxy coatings to steel piles shall consist of three coats of epoxy-based paint, each coat having a minimum dry film thickness of 75 \( \mu \)m. The first coat shall be applied within two hours of blast cleaning.

(2) The finished surface of epoxy coatings shall be smooth with a dense and uniform texture and shall be free of sharp protuberances and pinholes. The thickness and continuity of completed epoxy coatings shall be measured using a magnetic thickness gauge or by other methods agreed by the Engineer.

(3) Damaged areas of epoxy coatings shall be repaired by cleaning the damaged areas to bare metal, feathering back the adjacent areas with coarse grade sandpaper and re-applying the coating.

**Bituminous coatings to steel piles**

8.26  
(1) Bituminous coating material, or primer if the bituminous coating consists of a built-up system, to steel piles shall be applied within two hours of blast cleaning. The thickness of bituminous coatings shall be at least 300 \( \mu \)m.

(2) Damaged areas of bituminous coatings shall be over-coated with the same bituminous coating material to restore the specified thickness.

**Surface treatment of extended steel piles**

8.27  
The splice areas of steel piles, which are extended in-situ, shall be prepared by blast cleaning and the protective coating shall be applied to the area. Steel piles for marine works shall be spliced and the surface treatment applied to the splice areas before the piles are driven unless otherwise permitted by the Engineer.

**Removal of protective coatings to steel piles**

8.28  
Protective coatings shall be removed from the heads of steel piles which will be encased in concrete by blast cleaning, flame cleaning or by other methods agreed by the Engineer. The coatings shall be removed to a level of 75 mm above the underside of the concrete into which the pile will be encased.

**SUBMISSIONS**

**Particulars of piling works**

8.29  
(1) The following particulars of the proposed materials and methods of construction for piling works shall be submitted to the Engineer:

(a) Details of construction plant,

(b) Methods and sequence of installation of piles, including methods of avoiding damage to adjacent piles, structures and utilities and measures to be taken to deal with hard material and obstructions,

(c) Calculations of driving stresses,

(d) Methods of jointing and lengthening piles,

(e) Methods of controlling groundwater, or groundwater treatment,

(f) Anticipated ground vibration, ground movement and groundwater drawdown and methods of instrumentation and monitoring,
(g) Methods and sequence of excavation, including methods of supporting excavations and of cleaning the excavation,

(h) Methods of concreting,

(i) Details of protective coatings to steel piles, including manufacturers' literature,

(j) Details of preliminary piles, and

(k) Methods of testing, including details of the specialist firm for non-destructive testing of welds and the programme for integrity testing.

(2) The particulars shall be submitted to the Engineer at least 21 days before the relevant preliminary piles are constructed. If preliminary piles are not required, the particulars shall be submitted to the Engineer at least 21 days before the relevant piling works start.

**Particulars of construction using bentonite slurry**

8.30 (1) The following particulars of the proposed materials and methods of construction using a slurry containing bentonite or other agent shall be submitted to the Engineer:

(a) A certificate for bentonite showing the type, the manufacturer's name, the date and place of manufacture and including details of the apparent viscosity range in Pa.s and the gel strength range in N/m² for solids in water,

(b) Characteristics of the bentonite slurry in a freshly mixed condition and in the excavation immediately before concreting,

(c) Methods of quality control, sampling, testing, mixing, storing, recirculating, removing silt and sand, preventing spillages and disposal from the Site,

(d) Head of bentonite slurry, including stability calculations,

(e) Details of guide walls,

(f) Methods of placing concrete by tremie, and

(g) Sequence of construction.

(2) The particulars shall be submitted to the Engineer at least 21 days before the relevant excavation starts.

**Particulars of hand-dug caissons**

8.31 Particulars of the proposed materials and methods of construction for hand-dug caissons, including details of linings, shall be submitted to the Engineer at least 21 days before the relevant excavation starts.

**Particulars of minipiles**

8.32 (1) The following particulars of the proposed materials and methods of construction for minipiles shall be submitted to the Engineer:

(a) Details of reinforcement or pipe section, including spacers and couplings,
(b) Details of grout mix as stated in Clause 17.13, and
(c) Sequence and timing of grouting, including details of secondary pressure grouting.

(2) The particulars shall be submitted to the Engineer at least 7 days before trial mixes for grout are made.

HANDLING AND STORAGE OF MATERIALS

Handling and storage of piles 8.33

(1) The identification number, grade of steel and length of pile shall be marked on steel piles. The identification number, date of casting and length of pile shall be marked on precast concrete piles.

(2) Piles shall be stored horizontally off the ground on level supports and in a manner, which will not result in damage or deformation to the piles, or in contamination of the piles. Coated piles shall be handled and stored in a manner, which will not result in damage to the coatings. Bituminous-coated piles shall not be stacked.

(3) Different types and sizes of piles shall be stored separately.

Handling and storage of bentonite 8.34

Bentonite shall be handled and stored in a manner, which will not result in spillages on the Site.

GENERAL PILING WORKS REQUIREMENTS

Commencement of piling works 8.35

Piling works, including groundwater control and ground treatment for piling works, shall not commence until the relevant proposed materials and methods of construction, including construction and testing of preliminary piles, have been approved.

Prevention of damage due to piling works 8.36

(1) The position of existing utilities shall be determined and underground utilities adjacent to the piles shall be exposed or otherwise accurately located before piling works start.

(2) All necessary measures shall be taken to minimise the settlement of the ground and adjacent structures and utilities and to prevent the formation of cavities in the ground resulting from piling works.

(3) The vibrations due to piling works at structures, utilities and previously installed piles measured in terms of peak particle velocity shall not exceed 25 mm/s.

(4) The vibrations due to piling works at structures, utilities and previously installed piles measured in terms of vibration amplitude shall not exceed 0.2 mm.
### Monitoring of noise, vibration, ground movement and groundwater level

**8.37**

1. Measurements of noise level, vibration, ground movement and groundwater level shall be taken at locations and time intervals stated in the Contract or instructed by the Engineer when piling works are being carried out. Records of the measurements shall be kept and a copy of the records supplied to the Engineer. Arrangements for installing instruments and taking measurements both inside and outside the Site shall be made by the Contractor.

2. Measurements of noise level and vibration shall be made with instruments of a type agreed by the Engineer.

3. Sufficient numbers of piezometers and survey points shall be installed to allow the changing groundwater levels and the effects on structures, utilities and previously installed piles to be measured. Measurements shall be taken at regular intervals when groundwater control is carried out and until such time as the groundwater has resumed its natural regime.

4. The Contractor shall inform the Engineer immediately of any unanticipated change in measurements.

5. If the specified limits, or limits agreed by the Engineer, on vibration, groundwater movement or groundwater level are exceeded, the work causing the limits to be exceeded shall be stopped and particulars of proposed changes to the methods of construction shall be submitted to the Engineer for approval.

### Ground investigation for piling works

**8.38**

1. Before piling works start, boreholes of minimum NX size shall be sunk and piezometers shall be installed at locations stated in the Contract or instructed by the Engineer to determine the soil characteristics and the groundwater regime and to determine the founding level of non-displacement cast-in-situ piles.

2. Soil samples and rock samples stated in the Contract or instructed by the Engineer shall be taken from pile excavations for visual inspection and testing. The method of sampling and testing shall be as stated in Section 7.

### Ground investigation for piles founded on rock

**8.39**

All ground investigation for piles founded on rock, including pre-drilling and proof-drilling as well as any core-drilling on the constructed piles, shall be carried out by an independent Specialist Contractor for Public Works registered under the Work Category of "Ground Investigation Field Work", who is required to make a declaration that it is not a holding company, a subsidiary company, an associated company or a related party of the Contractor, and that it has no financial interests in the piling works to be tested.

### Pre-drilling for piles founded on rock

**8.40**

1. For piles founded on rock, sufficient pre-drilling should be carried out before the installation works, such that the quality of the founding rock can be identified and the appropriate founding levels can be determined. The pre-drilling should be sunk to at least 5m below the tentative founding rock levels of the piles.

2. Pre-drilling should be carried out for each of the large-diameter bored piles, barrettes and the like. For minipiles, socketted steel H-piles and similar small diameter-bored piles, founding on rock, the number of pre-drill boreholes required should be such that the pile tip of every such pile should be within 5 metres from a pre-drill hole, or at a larger distance from it as decided by the Engineer.
**Founding levels**

8.41  (1) The Contractor shall allow the Engineer to inspect the material at the proposed founding level and shall inform the Engineer immediately the founding level is reached.

(2) If instructed by the Engineer the founding level shall be proved by drilling to a depth of 4.5 m or three times the pile diameter, whichever is greater, below the founding level and obtaining samples of NX size.

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**PRELIMINARY PILES**

**Preliminary piles**

8.42  (1) Preliminary piles shall be constructed using the materials and methods of construction proposed for the working piles and which have been submitted to the Engineer. The location and details of preliminary piles shall be as instructed by the Engineer.

(2) Unless otherwise permitted by the Engineer the relevant piling works shall not commence until the construction, testing and records of the preliminary piles stated in the contract or instructed by the Engineer have been approved.

(3) Preliminary piles shall be left in position, cut off, incorporated in the permanent work or withdrawn and disposed of as stated in the Contract. Preliminary piles intended to be incorporated in the permanent work and which do not comply with the specified requirements shall be removed and disposed of or dealt with as instructed by the Engineer.

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**DRIVEN PILES**

**Supports for driven piles**

8.43  (1) Driven piles shall be supported and restrained by means of leaders, trestles, temporary supports or other guide arrangements in such a manner that:

   (a) The piles are maintained in position and alignment,

   (b) The piles are not loosened in the ground, and

   (c) Damage resulting from oscillation, vibration or movement of free-standing piles does not occur.

The supports and restraints shall be maintained at all times during driving and until the piles are incorporated into the structure.

(2) Unless otherwise permitted by the Engineer, driven piles for marine works shall be driven from fixed stagings. The stagings shall be rigid and strong enough to ensure that the piling works can be carried out efficiently and accurately.

**Use of diesel hammer**

8.44  The use of diesel hammer for percussive piling is prohibited.
Followers or long dollies shall not be used unless permitted by the Engineer. If permitted, the set shall be revised by the Contractor and agreed by the Engineer, to allow for the reduction in effectiveness of the hammer blows.

Marking of piles

Piles, including temporary and permanent casings, shall be marked at 1 m intervals before pitching.

Driving piles

(1) Unless otherwise permitted by the Engineer each pile, other than sheet piles, shall be driven without interruption until the required depth or set has been achieved. If a minimum depth of penetration is stated in the Contract, the Contractor shall submit to the Engineer his proposals for achieving this requirement and it shall be his responsibility to ensure that the minimum penetration and set are achieved without causing damage to the pile.

(2) The sequence and method of driving piles shall be such as to minimise the detrimental effects of heave and lateral displacement of the ground and to cause the least possible displacement to previously installed piles. Piles, including casings, shall not be driven within a centre to centre distance of 3 m or five times the diameter of the pile or casing, whichever is less, from an unfilled excavation or from an uncased concrete pile which has been cast for less than 48 hours.

(3) The Contractor shall inform the Engineer without delay of any sudden change in driving characteristics.

Driving concrete piles

(1) Concrete piles shall not be driven until the concrete has attained the specified grade strength.

(2) The driving stresses in precast reinforced concrete piles and prestressed concrete piles shall not exceed one half of the specified grade strength of the concrete. Calculations of the driving stresses shall be submitted to the Engineer.

Displaced piles

Piles that have been displaced as a result of driving adjacent piles shall be corrected. Particulars of the method of correction and measures to be taken to avoid displacement in subsequent driving shall be submitted to the Engineer for approval.

Re-drive checks

No re-drive checks shall be carried out within 24 hours of completion of first driving.

Lengthening driven piles

The strength of piles at joints shall not be less than the strength at any normal section of the pile. Lengthened piles shall not be driven until the joint has developed the designed strength. Pile joints shall be tested as stated in the Contract or as instructed by the Engineer.
Measurement of set of driven piles

(1) Set shall be measured for each driven pile at times agreed by the Engineer and in the presence of the Engineer. The final set shall be measured as either:

(a) Penetration per 10 blows, or

(b) The number of blows required to produce 25 mm penetration.

(2) If driving is interrupted for more than 30 minutes, except as otherwise agreed by the Engineer, set shall not be measured after driving restarts until at least 20 blows of the same driving energy as at final set have been struck.

(3) When final set is measured:

(a) The exposed part of the pile shall be in good condition without damage or distortion,

(b) The dolly and packing shall be in sound condition,

(c) The hammer blow shall be in line with the axis of the pile and the impact surfaces shall be flat and at right angles to the axes of the pile and hammer, and

(d) The hammer shall be in good condition and operating correctly.

(4) The temporary compression of each driven pile shall be measured.

(5) The Contractor shall inform the Engineer at least 1 hour before final set and temporary compression are to be measured.

CAST-IN-SITU CONCRETE PILES

Excavation for cast-in-situ piles

(1) Except as stated in Clause 8.54(1), excavation for cast-in-situ concrete piles shall be carried out by mechanical methods. Blasting and compressed air shall not be used unless permitted by the Engineer. Large-diameter bored piles shall be formed by boring, chiseling or grabbing and filled with concrete. Piles with enlarged bases shall not be used unless specified otherwise. Where so permitted, the enlarged base shall only be formed by underreaming with a reverse circulation drill. The relevant technique shall have been approved by the Environment, Transport and Works Bureau.

(2) The stability of excavations for cast-in-situ concrete piles shall be maintained where necessary by:

(a) Temporary casings,

(b) Permanent casings, or

(c) A thixotropic slurry containing bentonite or other agent.

(3) The bottom of casings shall be kept sufficiently deep to prevent the flow of soil into the casing.
HAND-DUG CAISSONS

**Excavation for hand-dug caissons** 8.54

(1) The Contractor shall adopt a method of construction that will not cause settlement or disturbance of any kind to adjacent structures, pavements, public or private services. The Contractor shall establish an approved monitoring system and take regular readings and prepare and submit reports to the Engineer in the format and quantity as requested. The Contractor shall modify the method of construction if the effects of ground movement are detected in any such structures, pavements and services.

(2) The minimum clear working space inside a caisson (i.e. excluding the lining) shall not be less than 1.8m diameter. Caissons with an enlarged base shall not be used unless otherwise specified.

(3) Excavation for hand-dug caissons shall be carried out using manual methods or power tools. Blasting shall not be used unless permitted by the Engineer. If blasting is permitted:

   (a) The position of blast holes and the size of charges shall be such that shattering of rock beyond the caisson is minimised,

   (b) The rock face shall not be shattered within the toe-in or bell-out zone at the bottom of the caisson, and

   (c) The caisson opening shall be covered to prevent the projection of fragments of material.

(4) The stability of excavations for hand-dug caissons shall be maintained where necessary by linings.

(5) In-situ concrete tapered rings used as permanent liners shall be at least 100 mm thick and shall not exceed 1 m deep. The rings shall be constructed with well-compacted concrete of Grade 20/20 or greater.

(6) Shaft linings shall be placed as soon as practicable and not more than 24 hours after each increment of excavation is complete.

(7) Voids between the lining and face of the excavation shall be filled with concrete of the same grade as the lining or with other materials agreed by the Engineer.

(8) Any unstable layers of subsoil encountered shall be stabilized by grouting or similar methods. No further excavation will be permitted until the stabilization works are completed.

**Sealing and scaling of hand-dug caissons** 8.55

(1) Leakage of groundwater through liners or into unlined shafts of hand-dug caissons shall be stopped by a method agreed by the Engineer.

(2) Loose rock on the faces of unlined shafts shall be scaled off and removed before concreting.
### BARRETTEs

**Excavation for barrettes** 8.56

1. Excavation for barrettes shall be carried out by mechanical methods. Blasting shall not be used unless permitted by the Engineer.

2. The stability of excavations for barrettes shall be maintained by a thixotropic slurry containing bentonite or other agent.

3. The height of guide walls for barrettes shall be such that the head of slurry is sufficient to ensure the stability of excavations and that excessive movements of the adjacent ground will not occur. The position, alignment and level of guide walls shall be checked at regular intervals agreed by the Engineer.

### MINIPILEs

**Excavation for minipiles** 8.57

1. The stability of excavations for minipiles shall be maintained where necessary by temporary casings or by other methods approved by the Engineer.

2. Temporary casings shall be used if excavation is carried out by wash boring methods or when water or air is used as a flushing medium.

3. The pressure of the water or air that is used as a flushing medium shall be regulated frequently to ensure that it does not induce significant disturbance to the surrounding geological strata, or cause hydraulic fracture of the ground.

4. Unless otherwise specified in the Contract or instructed by the Engineer, mini-piles are to be socketed into Grade III rock or better with minimum total core recovery of not less than 90%. Minimum length of rock socket for the piles is shown on the Drawings or determined on Site by the Engineer.

**Grouting trials for minipiles** 8.58

Grouting trials shall be carried out to demonstrate accurate control of water/cement ratio, consistency of mixing, satisfactory workability and achievement of strength requirements. The trial shall be carried out on one minipile which is representative of those which will be used in the permanent work and at a location agreed by the Engineer.

### CONSTRUCTION USING BENTONITE SLURRY

**Excavation using bentonite slurry** 8.59

1. Excavations for piles using bentonite slurry shall be filled with the slurry from the time that excavation commences until concreting is complete. The slurry shall be maintained at a level of at least 1 m above the level of the external groundwater and such that the slurry pressure exceeds the pressure exerted by the soil and ground water.

2. Subject to the Engineer’s approval and the availability of the necessary equipment, the Contractor may use polymer slurry as an alternative to bentonite slurry. The handling and disposal of polymer slurry shall follow the supplier’s recommendation and be subject to the Engineer’s agreement.
(3) If there is a loss of bentonite slurry from the excavation, which is sufficient to result in a lack of stability, and if instructed by the Engineer, the excavation shall be immediately filled with material agreed by the Engineer. The cause of the loss of slurry shall be investigated and excavation shall not recommence until remedial measures have been approved by the Engineer.

Mixing of bentonite slurry 8.60
(1) Bentonite shall be thoroughly mixed with water in a colloidal mixer. The water shall be taken from the public supply of potable water and shall be at a temperature of at least 5°C. The temperature of the bentonite slurry shall be at least 5°C when supplied to the excavation.

(2) If the groundwater is excessively saline or chemically contaminated, the bentonite shall be prehydrated or the bentonite slurry shall be modified such that the slurry is suitable for the support of the excavation.

Protection of bentonite slurry material 8.61
All solid additives shall be stored in a separate waterproof store with a raised floor or in a waterproof silo, which shall not allow the material to become contaminated.

Disposal of bentonite slurry 8.62
Bentonite slurry that will not be reused shall be disposed of from the Site as soon as practicable.

FIXING REINFORCEMENT FOR PILES

Fixing reinforcement for piles 8.63
Prefabricated reinforcement cages for piles shall be marked and fitted with spacers to ensure that the cage is correctly orientated and positioned within the pile. The reinforcement cage shall be lowered into position only in the daytime after the Engineer’s Representative has verified both the length of the reinforcement cage and the depth of the hole and after the base has been cleaned.

Temporary protection on pile head 8.64
Reinforcement protruding above a concreted pile shaft shall be protected against corrosion with cement paste that shall be removed before subsequent construction works commence. If the protection period is longer than a few weeks, weak concrete should be used instead of cement paste.

PLACING CONCRETE IN PILES

Cleaning and drying excavations for piles 8.65
(1) The bases of excavations for piles shall be cleaned by air-lifting or by other methods agreed by the Engineer before concrete is placed. If excavation is carried out under water, cleaning shall continue until the water is clear and free of particles of soil. Measures shall be taken to prevent the accumulation of silt and other material at the base of the excavation.

(2) If the rate of ingress of water does not exceed 0.3 L/s, the base of excavations for piles shall be dried immediately before concrete is placed.
Placing concrete in piles

8.66 (1) Each pile shall be concreted as soon as practicable after the permission of the Engineer has been obtained. If a tremie pipe is used, it must be watertight and of sufficient strength. The discharge end shall be maintained below the upper surface of the rising concrete at all times. Concrete shall be placed without interruption until the complete pile is concreted.

(2) If excavations for piles are supported by bentonite slurry or if the rate of ingress of water exceeds 0.3 L/s, the following shall be complied with:

(a) Concrete shall be placed by tremie unless otherwise permitted by the Engineer,

(b) The minimum cementitious content of the concrete shall be 375 kg/m³,

(c) The level of the top of the concrete in piles shall be at least 750 mm above the specified cut-off level,

(d) If the top of the guide wall for barrettes is at the specified cut-off level, concrete shall continue to be placed until the top of the pile is free of contamination, and

(e) After the concrete has hardened, excess concrete shall be removed to the specified cut-off level.

(3) Operations that in the opinion of the Engineer are likely to disturb or affect the concrete or placing of the concrete shall not be carried out unless agreed by the Engineer.

Removal of temporary casings to piles

8.67 (1) A sufficient quantity of concrete shall be maintained within temporary casings that are being withdrawn to ensure that the pressure from external water or soil is exceeded and that the pile is not reduced in section or contaminated.

(2) Temporary casings which are in contact with concrete and which are not withdrawn before the initial set of the concrete has taken place shall be left in place.

Empty bores above piles

8.68 Empty bores and shafts which remain above the pile after concrete has been placed shall be temporarily protected or filled with material agreed by the Engineer as soon as practicable.

INSPECTION OF PILING WORKS

8.69 The Contractor shall allow the Engineer’s Representative (ER) to inspect excavations for piles before placing concrete in the pile and at other times required by the Engineer. The ER shall decide on the most suitable method to be used for inspecting excavations (and the bases) and dipping the depth of the drilled hole personally and the Contractor shall provide all the necessary facilities and equipment to enable the ER to carry out the inspection/dipping in a safe manner. After the base of excavation has been cleaned as required by the Engineer, the Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before placing concrete in piles.
**Inspection of installed piles**

8.70 (1) If instructed by the Engineer, installed piles shall be exposed for inspection or testing. Excavations for exposing piles shall be of a depth agreed by the Engineer, and the face of the excavation shall be at least 750 mm from the face of the pile. The excavation shall be maintained in a stable condition and kept free of water.

(2) The surface of the pile shall be washed clean of all silt, mud or other adhering materials to permit inspection.

(3) After inspection, excavations for exposing piles shall be filled using special fill material that shall be compacted to obtain a relative compaction of at least 95% above the groundwater table.

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**TOLERANCES**

**Tolerances: steel bearing piles**

8.71 Dimensional tolerances of steel bearing pile sections shall comply with the relevant BS stated in Clause 18.04. Fabrication tolerances for steel bearing piles and related steelwork shall comply with BS 5950: Part 2.

**Tolerances: precast concrete piles**

8.72 The manufacturing tolerances for precast concrete piles shall comply with the following requirements:

(a) The external cross-sectional dimensions shall be within 0 mm and +6 mm of the specified dimensions.

(b) The wall thickness of hollow spun concrete piles shall be within 0 mm and +25 mm of the specified thickness.

(c) There shall be no irregularity exceeding 6 mm in a 3 m length along the face of the pile measured using a 3 m straight edge.

(d) There shall be no irregularity exceeding 25 mm in a 3 m length along the internal face of hollow spun concrete piles measured using a 3 m straight edge.

(e) The centroid of any cross-section of the pile shall not be more than 12 mm from the straight line connecting the centroids of the end faces of the pile. For the purpose of determining the centroid, the centroid of any cross-section of a hollow pile shall be determined by assuming that the pile has a solid section.

**Tolerances: hand-dug caissons**

8.73 The centre of each section of the shaft shall lie within 50 mm of the centreline of the whole shaft.

**Tolerances: pile installations**

8.74 (1) Piles, including hand-dug caissons and mini-piles, shall be installed to within the tolerances stated in Table 8.1.

(2) Piles that do not comply with the specified tolerances shall not be forcibly corrected.
Table 8.1: Tolerances of installed piles

<table>
<thead>
<tr>
<th>Description</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land piles</td>
</tr>
<tr>
<td>Deviation from specified position in plan, measured at cut-off level</td>
<td>75 mm</td>
</tr>
<tr>
<td></td>
<td>15 mm for minipiles</td>
</tr>
<tr>
<td>Deviation from vertical</td>
<td>1 in 75</td>
</tr>
<tr>
<td></td>
<td>1 in 300 for large-diameter bored piles or hand-dug caissons</td>
</tr>
<tr>
<td></td>
<td>1 in 100 for minipiles</td>
</tr>
<tr>
<td>Deviation of raking piles from specified batter</td>
<td>1 in 25</td>
</tr>
<tr>
<td>Deviation from specified cut-off level</td>
<td>25 mm</td>
</tr>
</tbody>
</table>

The diameter of cast in-situ piles shall be at least 97% of the specified diameter.

RECORDS OF PILING WORKS

Records of piles delivered/constructed in situ 8.75

Records of prefabricated piles shall be kept by the Contractor on the Site and submitted to the Engineer at the time the piles are delivered to the Site. The records shall include test certificates, analyses and mill sheets for steel piles and proprietary piles. Records of cast-in-situ piles shall be signed by the Engineer after he has carried out the inspection/verification personally.

Records of pile driving 8.76

Records of pile driving shall be kept by the Contractor on the Site and submitted to the Engineer within 24 hours after the driving or installation of each pile has been completed. The records shall be kept on standard forms as shown in Appendices 8.2 to 8.5 and shall be available for inspection by the Engineer.

Records of bentonite slurry 8.77

Records of tests on bentonite slurry shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer at times agreed by the Engineer. The records shall be kept on standard forms as shown in Appendix 8.6 and shall be available for inspection by the Engineer.

Records of load tests on piles 8.78

Records of load tests on piles shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 48 hours after the test has been completed. The records shall be kept on standard forms as shown in Appendix 8.7 and shall be available to the Engineer for inspection. The records shall include graphs showing load and settlement versus time, plotted in the format shown in BS 8004, Figure 15(a).
Records of integrity tests on piles 8.79

Records of integrity tests on piles shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer not more than 3 days after the test has been completed. The records shall be available to the Engineer for inspection. The report shall contain the following details:

(a) Details stated in Clause 1.42,
(b) Pile reference numbers,
(c) Measured pile length,
(d) Defects such as cracks, fractures or discontinuities, and
(e) Pile stiffness.

Record drawings 8.80

Record drawings of installed piles shall be prepared by the Contractor and two copies shall be submitted to the Engineer within 14 days of completing the piles, including cutting and trimming, in each pile group or building block. The drawings shall include the as-constructed co-ordinates of the centre of each pile at cut-off level, the final depth and cut-off level of each pile and other information required by the Engineer.

Record of piling works 8.81

Within 14 days of completing the piles in each pile group or building block for minipiles, socketted steel H-piles and small-diameter bored piles, the Contractor shall submit to the Engineer a piling record plan showing the following:

(a) The top levels of the rock sockets;
(b) The bottom levels of the rock sockets;
(c) The lengths of the rock sockets; and
(d) The contours of the rock-head inferred from drill hole logs.

TESTING: LOAD TESTS ON PILES

Testing: load tests on piles 8.82

(1) The number of piles to be tested by load testing shall be as stated in the Contract, or as instructed by the Engineer.

(2) The piles shall be tested to determine the settlement of the pile under load. Testing shall be carried out in accordance with a procedure agreed by the Engineer. The method of testing shall be as stated in Appendix 8.1.

(3) Piles shall not be tested until the concrete or grout has attained sufficient strength to withstand the tests. The tests shall be carried out within 28 days of the Engineer's instruction to carry out the test unless otherwise agreed by the Engineer.
| Compliance criteria: load tests on piles | 8.83 | Unless otherwise stated in the Contract, on completion of testing in accordance with Clause 8.82 the results of load tests on piles shall comply with the following requirements:

(a) The settlement at any load shall be less than twice the settlement at 90% of that load (Brinch Hansen's criteria),

(b) Under working load the gross pile head settlement shall not exceed 20 mm for buildings and 10 mm for other structures, and

(c) The preliminary pile shall have a factor of safety of at least 2.

| Non-compliance: load tests on piles | 8.84 | If the result of any load test on piles does not comply with the specified requirements for settlement, the Contractor shall submit remedial proposals to the Engineer for approval.

| Proof drilling | 8.85 | (1) Proof drilling shall be carried out on every large-diameter bored pile to check the condition at the concrete/rock interface. A base coring tube of at least 150 mm diameter shall be left at about 1000 mm above the founding level of the pile. The core-drilling shall be carried out to 1000 mm below the concrete/rock interface.

(2) Proof drilling shall be carried out to verify the adequacy of the socketted length of minipiles and socketted steel H-piles at locations as instructed by the Engineer. The number of proof drilling shall be at least 2 or 1% of the number of piles rounded up to the next higher whole number, whichever is the greater. The depths of the proof drill holes shall be at least 5 metres below the founding levels of the adjoining piles.

---

### TESTING: CONCRETE CORES FROM PILES

| Samples: concrete cores from piles | 8.86 | (1) The number of concrete cores to be provided for testing from concrete piles shall be as stated in the Contract or as instructed by the Engineer. The positions from which the cores are taken shall be as instructed by the Engineer.

(2) Concrete cores shall be 100 mm diameter.

(3) The method of taking concrete cores shall be in accordance with CS1.

(4) Holes formed by taking concrete cores from piles shall be reinstated using an approved concrete mix or an approved grout mix.

(5) Prestressed precast concrete piles from which concrete cores have been taken shall be abandoned.

| Testing: concrete cores from piles | 8.87 | (1) Each concrete core from a pile shall be inspected for evidence of segregation of the constituents and for the presence of voids. Specimens selected from each core shall be tested to determine the compressive strength.

(2) The method of preparing, inspecting and testing concrete cores shall be as stated in Clause 16.64(2).
Compliance criteria:  
concrete cores from piles

The compliance criteria for concrete cores from piles shall be as stated in Clause 16.65.

Non-compliance:  
concrete cores from piles

(1) If the result of any test on a concrete core from a pile does not comply with Clause 16.65 additional cores shall be taken from the same pile and additional tests shall be carried out.

(2) Additional concrete cores shall be 100 mm diameter for concrete of 20 mm nominal maximum aggregate size and 150 mm diameter for concrete of 40 mm nominal maximum aggregate size. The number of additional cores shall be as instructed by the Engineer.

(3) If the result of any additional test does not comply with the compliance criteria for concrete cores the Contractor shall submit remedial proposals to the Engineer for approval. The number of additional piles and additional tests shall be as instructed by the Engineer.

TESTING: NON-DESTRUCTIVE TESTS ON WELDS IN PILES

Testing: non-destructive tests on welds in piles

(1) The number and type of non-destructive tests on welds in piles shall be as stated in the Contract or instructed by the Engineer.

(2) Radiographic tests shall comply with BS 2600: Part 1 and ultrasonic tests shall comply with BS 3923: Part 2.

Non-compliance: non-destructive tests on welds in piles

If the result of any test on a weld in a pile does not comply with the specified requirements, the complete weld shall be cut out, the joint shall be re-welded and the weld shall be tested.

TESTING: INTEGRITY TESTS

Testing: integrity testing on piles and non-destructive integrity testing

(1) The number and type of integrity tests to be carried out on piles shall be as stated in the Contract.

(2) Integrity testing shall be carried out in sufficient time before the relevant piling works start to permit the tests to be carried out.

(3) The results of integrity tests shall be used to enable the Engineer to select piles for further testing.

(4) Non-destructive integrity tests, if required, shall be carried out by an independent Testing Firm as agreed by the Engineer. The Contractor shall provide attendance and other preparatory works as required. The Contractor shall provide the Testing Firm with a copy of the ground investigation report, a Site plan showing bore hole locations and pile layout and a list of the piles to be tested with the date of concreting, total length, length of casing (if any), diameter and volume of concrete used plus any other relevant information required for the testing of the pile.
If the result of any integrity test on a pile does not comply with the specified requirements, additional tests shall be carried out. The number of additional tests shall be as instructed by the Engineer.

(1) Before concreting, the Contractor shall install 4 nos. (which may be reduced to 3 nos. if the pile shaft is too congested to accommodate 4 nos.) watertight steel tubes of not less than 50 mm internal diameter and without internal projections over the full depth of each of the bored cast-in-situ piles. The tubes shall extend from between 0.2 m to 0.5 m above the pile head to within 0.1 m to 0.2 m of the pile toe. The tubes shall be firmly tied to the reinforcement cage, placed parallel to each other, equally spaced around the circumference, and at a constant cover (75 mm minimum to 100 mm maximum) to the external face of the pile. The tubes shall be straight and continuous and shall be filled with water and adequately sealed at both ends before concreting.

(2) Sonic tests shall be carried out for all bored cast-in-situ piles unless otherwise agreed by the Engineer. An independent specialist-testing consultant appointed by the Contractor and approved by the Engineer shall conduct the tests to verify the homogeneity and integrity of the hardened concrete. The Contractor shall submit the proposed procedures for sonic tests to the Engineer for approval at least 14 days before concreting.

(3) The equipment for sonic testing shall consist of a signal transmitter probe and a signal receiver probe, which may be lowered into the tubes installed in the piles either in tandem or singly. The results of the sonic testing shall be displaced on a recording oscilloscope at the top of the pile.

(4) The signal emitted by the transducer shall be in the spectrum of 100Hz to 60kHz and of variable emission pulse rate between 1 and 20 cycles per second to suit the testing requirements.

(5) The recording oscilloscope shall be of the storage type with signal modulation representation of the received signal on a horizontal tracing: bright spots correspond to peaks and signal blanks to troughs.

(6) For one-tube installation, a single log shall be taken with probes set 1m apart in the same tube. For two or more tubes, measurements shall be taken between adjacent tubes plus one diagonal where applicable.

(7) The Contractor shall ensure that the probe matches the tube diameter to minimize concrete-tube-probe signal alternation or misleading results will arise.

(8) Results shall be in the form of time delay versus pile depth. The results shall be recorded on the oscilloscope screen and photographed. The testing consultant shall submit the test reports and photographic traces directly to the Engineer within 48 hours of making the tests. The submitted materials shall become the property of the Employer.

(9) Voids formed by the steel tubes shall be pressure-grouted in accordance with the Contract at such times as agreed with the Engineer.
**TESTING: BENTONITE SLURRY**

### Samples: bentonite slurry

8.95 (1) Samples of bentonite slurry shall be provided for testing at a frequency agreed by the Engineer. Samples for testing to determine the density of the slurry shall be provided each day. A sample of bentonite slurry taken from the base of the excavation shall be tested to determine the density of the slurry before placing of concrete.

(2) The method of sampling and the sampling apparatus shall be as agreed by the Engineer.

### Testing: bentonite slurry

8.96 (1) Each sample of bentonite slurry shall be tested to determine the density, viscosity, shear strength and pH value.

(2) The method of testing shall be as stated in Table 8.2.

(3) The measuring device for testing density shall be readable and accurate to ± 0.005 g/mL.

(4) Samples to be tested for viscosity using the Fann viscometer shall be screened before testing using a 300 µm BS test sieve.

### Compliance criteria: bentonite slurry

8.97 (1) The results of tests on bentonite slurry shall be as stated in Table 8.2.

(2) Tests to determine the shear strength and pH value shall be discontinued if the results of tests indicate that a consistent working pattern has been established, taking account of the mixing process, blending of freshly mixed and previously used slurry and processes used to remove impurities from previously used slurry. If there is a subsequent change in the established working pattern, the tests to determine shear strength and pH value shall be reintroduced unless otherwise permitted by the Engineer.

### Non-compliance: bentonite slurry

8.98 If the results of tests for density and viscosity do not comply with the specified requirements, or if the results of tests for shear strength or pH value do not indicate a consistent working pattern, the bentonite slurry shall be deemed unsuitable for the work and concrete shall not be placed in the slurry. The slurry shall be replaced or its composition adjusted before concrete is placed.
Table 8.2: Properties of bentonite slurry and methods of testing

<table>
<thead>
<tr>
<th>Property at 20°C</th>
<th>Test results</th>
<th>Method of testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density as supplied to excavation</td>
<td>≤ 1.10 g/mL</td>
<td>Mud density balance</td>
</tr>
<tr>
<td>Density at base of excavation before placing concrete</td>
<td>≤ 1.25 g/mL</td>
<td>Mud density balance</td>
</tr>
<tr>
<td>Viscosity</td>
<td>30 – 50 seconds</td>
<td>Marsh cone method or Fann viscometer</td>
</tr>
<tr>
<td></td>
<td>≤ 0.02 Pa.s</td>
<td></td>
</tr>
<tr>
<td>Shear strength (10 minute gel strength)</td>
<td>1.4 – 10 N/m²</td>
<td>Shearometer or</td>
</tr>
<tr>
<td></td>
<td>4 – 40 N/m²</td>
<td>Fann viscometer</td>
</tr>
<tr>
<td>pH value</td>
<td>8 – 12</td>
<td>pH indicator paper strips or electrical pH meter</td>
</tr>
</tbody>
</table>
APPENDIX 8.1

DETERMINATION OF THE SETTLEMENT OF PILES BY LOAD TEST

Scope 8.1.1 This method covers the determination of the settlement of piles by means of a load test.

Equipment 8.1.2 The following equipment is required:

(a) Kentledge, anchor piles or other anchorages supported or installed at suitable locations to provide adequate reactions against jacking.

(b) A load-measuring device which shall consist of a load column, pressure cell, or other appropriate system, calibrated before and after each series of tests, or whenever adjustments are made to the device, or at time intervals recommended by the manufacturer of the equipment.

(c) Four deflectometers accurate to 0.025 mm.

(d) Precision levelling equipment accurate to 0.25 mm.

(e) A reference frame for supporting deflectometers and providing a datum for deflectometer measurements.

(f) Working platforms.

(g) Screens and protection from exposure to conditions which may affect the test.

(h) Hydraulic loading equipment.

Procedure: before testing 8.1.3 The procedure before testing shall be as follows:

(a) The kentledge, anchor piles or other anchorages shall be installed. The centre of each anchor pile shall be at least 2 m or three times the pile diameter, whichever is greater, from the centre of the pile to be tested and from the centre of any adjacent pile.

(b) If required, the pile to be tested shall be extended from cut-off level to ground level. The strength of piles at joints shall not be less than any normal section of the pile.

(c) A temporary square pile cap designed by the Contractor shall be constructed.

(d) Working platforms, screens and protection shall be installed.

(e) The reference frame shall be set up on supports which are at least 2 m or three times the pile diameter, whichever is greater, from the test pile and anchor pile. The four deflectometers shall be mounted on the reference frame to measure the deflection of the four corners of the temporary pile cap.
Procedure: load test

8.1.4 The procedure for the load test shall be as follows:

(a) Preliminary piles shall be tested to not less than twice the working load of the pile or other loads stated in the Contract. Working piles shall be tested to not less than 1.8 times working load. Reductions for group or boundary effects shall not be made in determining the test loads.

(b) Test loads shall be applied and removed in three stages as stated in Table 8.1.1.

(c) Unless otherwise permitted by the Engineer, the test loads shall be applied in increments, and removed in decrements, of 25% of the working load. Increments of load shall not be applied until the rate of settlement of the pile is less than 0.1 mm in 20 minutes.

(d) The full test loads for Stage I shall be applied in increments and shall then be maintained for at least 24 hours after the rate of settlement has reduced to less than 0.1 mm per hour. The test loads shall be removed in decrements and the recovery of the pile determined before loading is resumed.

(e) The procedure stated in Clause 8.1.4(d) shall be repeated for Stage II loading.

(f) The procedure stated in Clause 8.1.4(d) shall be repeated for Stage III loading unless the Engineer instructs the loading to be maintained for a longer period.

(g) The settlement of the pile shall be measured at hourly intervals or other intervals agreed by the Engineer. The settlement of the pile under each increment and decrement of loading shall be measured. The exact times at which increments are applied and decrements are removed shall be recorded. Settlements shall be measured and times shall be recorded in the presence of the Engineer.

(h) The level of the reference beam shall be checked at regular intervals agreed by the Engineer during the test.

Table 8.1.1: Test loading stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>Test load</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>25% of max. test load</td>
</tr>
<tr>
<td>II</td>
<td>50% of max. test load</td>
</tr>
<tr>
<td>III</td>
<td>100% of max. test load</td>
</tr>
</tbody>
</table>
### Procedure: after testing

8.1.5 After testing, equipment shall be removed, temporary pile caps shall be demolished and pile extensions shall be removed to cut-off level. Unless otherwise permitted by the Engineer, anchor piles shall be withdrawn.

### Reporting of results

8.1.6 The following shall be reported:

(a) The loads applied to the nearest 0.05 t.

(b) The settlement of the pile to the nearest 0.05 mm at hourly intervals and under each increment and decrement of loading.

(c) The exact times at which increments were applied and decrements removed.

(d) The levels of the reference beam, to the nearest 0.05 mm.
APPENDIX 8.2

PILE DRIVING RECORD

(Precast concrete, prefabricated steel and driven cast-in-place piles)

Contract No. __________________________ Title __________________________

Contract No. __________________________

Pile data

Reference No. __________________________ Location __________________________

Type __________________ Size __________________ Rake __________________

For precast concrete and steel piles; Preformed length __________________

For precast concrete piles; Date of casting __________________

Drive system data

Hammer: type _______ mass _______ kg drop (at set) _______ mm rated energy _______ kJ

Helmet, dolly & anvil: type __________________ mass __________________ kg

Packing: type __________________ Condition __________________ thickness __________________ mm

Levels

Commencing ground/sea bed* level (PD/CD)* __________________

Depth of overburden/height of working platform above sea bed level __________________

Reference working level/platform level* __________________

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Drop (m)</th>
<th>Depth penetrated (m)</th>
<th>No. of blows +</th>
<th>Cumulative No. of blows</th>
<th>Length of individual segments, location of splices and tests carried out</th>
<th>Remarks (State details of obstruction, delays, interruptions and location of concrete samples)++</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+ per 0.25 m for top 3.0 m of pile
++ for cast in place piles

(*delete as appropriate)
# PILE DRIVING RECORD

(Precast concrete, prefabricated steel and driven cast-in-place piles)

<table>
<thead>
<tr>
<th>Temporary compression record</th>
<th>(on graph paper graduated in millimetres to be pasted in space below)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Final penetration depth</th>
<th>Top of pile level</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temporary compression</th>
<th>Cut off level</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final set</th>
<th>Pile head level</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm/last 10 blows</td>
<td></td>
</tr>
<tr>
<td>or</td>
<td>Final toe level</td>
</tr>
<tr>
<td>blows/25 mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deviation from plumb or rake 1 in</th>
<th>Deviation at cut-off level x-x</th>
<th>Deviation at cut-off level y-y</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
</tbody>
</table>

## For driven cast-in-place piles:

<table>
<thead>
<tr>
<th>Length of temporary casing</th>
<th>Length of permanent casing</th>
<th>Length of cage reinf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>m</td>
<td>m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concrete grade</th>
<th>Date of concreting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Theoretical volume of concrete required</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>mm$^3$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actual volume of concrete placed</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>mm$^3$</td>
<td></td>
</tr>
</tbody>
</table>

Reported by ____________________________  Verified by ____________________________
Contractor’s Representative  *IOW / Engineer / Architect

Date ____________________________  Date ____________________________

(*delete as appropriate)
# APPENDIX 8.3

## PILE DRIVING RECORD

(Bored cast-in-place piles)

Contract No. _______________________________ Title _______________________________

Contractor _______________________________________________________________________

## Pile data

Reference No. ______________________________ Location ______________________________

Type _______ Diameter _______ mm Design Length _______ mm Rake 1 in _______

## Bore hole record

Commencing ground/sea bed* level (P.D./C.D.)* ______________________________________

Depth of overburden/height of working platform above sea bed level ______________________ m

Casing/drilling fluid* type ______________________________

Reference working level/platform level* ______________________________

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Depth penetrated</th>
<th>Details of strata penetrated/ground water level</th>
<th>Details of soil testing, proving of bedrock and under-ream</th>
<th>Remarks (State details of obstruction, delays interruptions, and location of concrete samples)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviation from plumb or rake 1 in _______ Deviation at cut-off level x-x _______

y-y _______

Length of temporary casing _______ m Length of permanent casing _______ m

(*delete as appropriate)
# PILE DRIVING RECORD

(Bored cast-in-place piles)

## Bore hole condition before concreting

- Bottom Visible/invisible* Measured depth of bore _______________ m
- Depth of water/drilling fluid* _______________ m
- Damage and debris observations _______________

## Concrete record

- Concreting in dry/by tremie* Water inflow rate __________ litres/second
- Concrete grade _______________ Slump _______________
- Actual concreted level _______________ Cut off level _______________
- Overall \( \frac{Lt}{La} \) = ________

Length of cage reinforcement _______________ m

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Delivery note No./Truck load No.</th>
<th>Quantity (m³)</th>
<th>Theoretical length filled Lt (m)</th>
<th>Actual Length Placed La (m)</th>
<th>Lt/La %</th>
<th>Cumulative length placed (m)</th>
<th>Remarks (Interruptions in placing, cause of excessive ( \pm \frac{Lt}{La} % ), Location of concrete samples, Ref. No. of cubes taken, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reported by ____________ Contractor’s Representative  Verified by ____________ *IOW / Engineer / Architect

Date _______________  Date _______________

Note: The Engineer shall be informed of any deviation greater than \( \pm 10\% \) from the expected (theoretical) level of concrete placed.

(*delete as appropriate)
APPENDIX 8.4

PILE RECORD

(Piles cast in-hand-dug Caissons)

Contract No. __________________________ Title __________________________

Contractor _________________________________________________________

Pile data

Reference No. __________________________ Location _______________________

Caisson Type __________________________ Diameter __________ mm Design Length __________ mm

Excavation Data

Commencing ground level (PD) __________________________ Depth of overburden __________________________ m

<table>
<thead>
<tr>
<th>Date</th>
<th>Depth reached (m)</th>
<th>Details of Strata penetrated/surrounding ground water level</th>
<th>Details of soil testing, proving of bedrock, and under-ream</th>
<th>Remarks (State details of obstructions, interruptions and delays)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviation from plumb 1 in ____________ Deviation at cut-off level x-x ____________ mm

y-y ____________ mm

Bedrock level* ____________ Water level* ____________

Base level of shaft ____________ Diameter of bell-out* ____________ mm

Length of toe-in* ____________ mm Depth of bell-out ____________ mm

* If none write ‘N/A’
PILE DRIVING RECORD
(Piles cast in hand-dug caissons)

Concrete record
Concreting in dry/by tremie*  Water inflow rate ________________ litres/second
Concrete grade ________________  Slump ___________________________
Actual concreted level ________________  Cut off level ________________
Overall \( \frac{L_t}{L_a} = \) ________________ %
Length of cage reinforcement ________________ m

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Delivery note No./ Truck load No.</th>
<th>Quantity (m³)</th>
<th>Theoretical length filled Lt (m)</th>
<th>Actual Length Placed La (m)</th>
<th>( \frac{L_t}{L_a} % )</th>
<th>Cumulative length placed (m)</th>
<th>Remarks (Interruptions in placing, cause of excessive ( \pm \frac{L_t}{L_a} % ), Location of concrete samples, Ref. No. of cubes taken, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Reported by ___________________________  Verified by ___________________________
Contractor’s Representative  *IOW / Engineer / Architect

Date ___________________________  Date ___________________________

Note: The Engineer shall be informed of any deviation greater than ±10% from the expected (theoretical) level of concrete placed.

(*delete as appropriate)
APPENDIX 8.5

PILE RECORDS

(Barrettes)

Contract No. ____________________ Title _____________________________

Contractor ________________________________________________________

**Pile data**

Reference No. ____________________ Location __________________________

Size of barrette ____________________ Shape __________________________

Design Length ____________________ m

**Excavation Data**

Commencing ground level (PD) _____________ Depth of overburden _____________ m

Guide wall levels: top ____________________ bottom _______________________

<table>
<thead>
<tr>
<th>Date</th>
<th>Depth reached (m)</th>
<th>Details of Strata penetrated/surrounding ground water level</th>
<th>Details of soil testing, proving of bedrock, and under-ream</th>
<th>Remarks (State details of obstructions, interruptions and delays)</th>
</tr>
</thead>
</table>

Deviation from plumb 1 in ________________ Deviation at cut-off level x-x ________________ mm

y-y ________________ mm

Base level of excavation ______________________

Depth of base from top of guide wall ______________________ m
PILE RECORD

(Barrettes)

Concrete record

Concrete grade ___________________________ Slump ___________________________

Actual concreted level ___________________ Cut off level _______________________

Overall \[ \frac{Lt}{La} \] %

= \[ \frac{Lt}{La} \] %

Length of cage reinforcement _____________ m

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Delivery note No./Truck load No.</th>
<th>Quantity (m³)</th>
<th>Theoretical length filled Lt (m)</th>
<th>Actual Length Placed La (m)</th>
<th>( \frac{Lt}{La} ) %</th>
<th>Cumulative length placed (m)</th>
<th>Remarks (Interruptions in placing, cause of excessive ( \pm \frac{Lt}{La} )%), Location of concrete samples, Ref. No. of cubes taken, etc.)</th>
</tr>
</thead>
</table>

Reported by ________________________       Verified by ________________________
Contractor’s Representative           *IOW / Engineer / Architect

Date ________________________       Date ________________________

Note: The Engineer shall be informed of any deviation greater than ±10% from the expected (theoretical) level of concrete placed.

(*delete as appropriate)
# APPENDIX 8.6

## BENTONITE SLURRY RECORD

<table>
<thead>
<tr>
<th>Contract No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Contractor</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sample data

<table>
<thead>
<tr>
<th>Ref. No. of pile</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source of test sample:
- (a) freshly mixed slurry*
- (b) as supplied to excavation*
- (c) from bottom of excavation before placing concrete

Date & time of sampling

<table>
<thead>
<tr>
<th>Test Method and Apparatus Used</th>
<th>Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/mL)</td>
<td></td>
</tr>
<tr>
<td>Viscosity (seconds)</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
</tr>
<tr>
<td>Sand Content (%)</td>
<td></td>
</tr>
<tr>
<td>Fluid Loss (mL)</td>
<td></td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td></td>
</tr>
</tbody>
</table>

### Remarks:

- 
- 
- 
- 
- 

Reported by ____________________________  
Contractor’s Representative  
Verified by ____________________________  
*IOW / Engineer / Architect

Date ________________  
Date ________________

(*delete as appropriate)
APPENDIX 8.7

PILE LOAD TEST RECORD

(Test result)

Contract No. __________________________ Title __________________________
Contractor __________________________

Pile data
Reference No. __________________________ Location __________________________
Type __________________________ Size __________________________
Pile dia/diagonal width (D) __________________________ Cross pile length (Lp) __________________________
Sectional area (A) __________________________ Young’s modulus (E) __________________________

Testing data
Design working load (P) __________________________
Test load (Q) = 2 (P) __________________________
Pressure gauge No. _______ Calibration Certificate ref. _______ Date _______

<table>
<thead>
<tr>
<th>Dial gauge number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td>Serial number</td>
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<td></td>
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<tr>
<td>Calibration certificate ref.</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Date of calibration</td>
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</tbody>
</table>

Level of fixed point on load reaction system: before testing __________________________
                                      after testing __________________________
                                      ground settlement = __________________________

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Load (kN)</th>
<th>Pressure Gauge Reading</th>
<th>Dial Gauge Readings</th>
<th>Cumulative Settlement (mm)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dial 1</td>
<td>Dial 2</td>
<td>Dial 3</td>
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</table>

8.37
### PILE LOAD TEST RECORD

*(Testing result)*

<table>
<thead>
<tr>
<th>Load in kN</th>
<th>1000</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
<th>5000</th>
<th>6000</th>
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</thead>
<tbody>
<tr>
<td>Settlement in mm</td>
<td>0</td>
<td></td>
<td></td>
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<tr>
<td>Settlement in mm</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Settlement in mm</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Settlement in mm</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Settlement in mm</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Settlement in mm</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Settlement in mm</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Settlement in mm</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Settlement in mm</td>
<td>40</td>
<td></td>
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</tbody>
</table>

**Maximum settlement at working load:**

(Allowable = 20 mm for buildings and 10 mm for all other structures.)

Actual = _______________________

**Settlement at maximum test load (S₁):**

(Allowable = S₁ less than twice settlement at 90% of maximum test load (2S₂).)

Actual $S₁ = \quad 2S₂ = \quad$ _______________________

Reported by _______________________

Contractor’s Representative

Verified by _______________________

*IOW / Engineer / Architect

Date _______________________

Date _______________________

(*delete as appropriate)