

## **SPECIFICATION FOR CAISSON CONSTRUCTION**

### **1.0 METHOD OF EXCAVATION**

Caissons shall be hand-excavated but the use of hand-held air tools is permitted. Full details of support and safety measures and any dewatering and/or grouting shall be submitted to the Engineer for approval prior to excavation.

The method of excavation used shall not give rise to any condition that might cause damage to adjacent roads, services, structures or properties. The Contractor shall be responsible for any damage and the consequence thereof, which may arise due to the method of construction adopted.

### **2.0 BLASTING SHALL NOT BE ALLOWED IN THE CAISSON EXCAVATION**

Blasting shall be carried out only if approved by the Engineer. If approval is granted, the Contractor shall be responsible for obtaining all necessary permits and shall comply with the requirements of all relevant authorities.

### **3.0 DEPTH OF EXCAVATION**

The anticipated depths of all caissons shown on the Drawings are indicative only and shall not relieve the Contractor of any of his responsibilities under the contract. All caissons shall be taken to a depth pre-determined by the Engineer into the required bearing stratum over the full area of the caisson base. The caisson base shall be levelled. Where bell-outs are required they shall be formed entirely within the bearing stratum.

### **4.0 OBSTRUCTIONS**

All obstructions, whether naturally occurring or otherwise, met during the course of excavation shall be removed. This shall include all boulders, old concrete, brick, steel or timber foundations, and roots and buried tree trunks, non-serviceable drains, manholes and gulleys or any other obstructions. The open ends of any such drains etc. shall be sealed with concrete and all voids filled in with granular materials.

### **5.0 CONCRETE LINING**

All caissons shall be lined down to founding level during construction. All linings shall be designed by the Contractor and be of concrete minimum Grade 25 Designed Mix or as otherwise shown in the Drawings and shall be capable of withstanding the pressures of the surrounding soil and water without deformation, cracking, or any form of instability. The linings shall effectively seal the caissons from ingress of water and shall prevent movement of ground into the excavation. Except as stated herein and on the Drawings, the linings shall be designed by the Contractor with all details and calculations submitted for approval. These details shall include lining thickness, method of construction, reinforcement details and the minimum period of retaining formwork in position before striking, etc.

Linings shall be constructed immediately after excavation and in sufficiently short sections to prevent inflow of soil or excessive inflow of water. The depth of unsupported (unlined) excavation in all caissons shall at no time exceed 1.5m unless approved in writing by the Engineer. Prior to placing concrete, pre-fabricated circular formwork shall be placed over the unsupported length of excavation. The position of formwork shall be checked by surveying prior to concreting in order to ensure correct alignment and achieve the tolerances specified.

Concrete shall be placed as soon as practicable and in no case later than 12 hours after excavation. The concrete shall be cast tight up against the sides of the excavation. If the excavation is larger than that shown on the Drawings, additional concrete shall be placed to fill the over-excavation. No backfilling using soil or rock or other material shall be allowed.

All caissons lining shall extend a minimum of 0.75m above the adjacent surrounding ground at all times. Suitable approved survey pins shall be cast into the lining above ground level and these shall be used to check the alignment of the formwork as the excavation progresses.

## **6.0 PROVING OF ROCK BELOW CAISSON BASE**

The rock below each caisson base shall be verified and tested to confirm its bearing capacity before concreting by sinking minimum 'NW' size drill holes (eg. 75mm diameter), as specified on the Drawings, to a minimum of 5m below the proposed caisson base level or 3 times the bell out diameter of the caisson whichever is the greater unless otherwise specified by the Engineer. Point load strength test shall be carried out on all rock cores recovered at 1m centers to confirm the rock strength.

## **7.0 INSPECTION OF THE CAISSON BASE**

The base of each caisson must be approved by the Engineer before any concreting is carried out. Each caisson base shall be inspected, logged and photographed by a qualified engineer from the Contractor approved by the Engineer.

Prior to inspection, the base of each completed excavation shall be carefully trimmed and levelled to within  $\pm 100\text{mm}$  of the proposed toe level and all loose or disturbed material shall be removed. Approval of the base of any caisson by the Engineer shall not relieve the Contractor of his responsibilities and obligations under the terms of the Contract.

## **8.0 RECORD OF CAISSON BASE**

Two copies of the preliminary log and photographs shall be supplied to the Engineer for approval of each caisson base. The format of log shall be agreed with the Engineer prior to commencing construction. Two copies of the final log shall be supplied to the Engineer within one week after inspection of each caisson base.

## **9.0 DEWATERING**

A comprehensive method statement on dewatering for caisson construction shall be submitted by the Contractor for approval.

As a minimum measure, individual caissons shall be kept dry during excavation and inspection by pumping from a sump or pilot hole within each caisson as necessary. Submersible pumps shall be used and placed in a sump not more than 0.6m deep and approximately 0.5m diameter sunk in advance of the main excavation. Pump operation shall be continuous until the concreting of caisson commenced.

The Contractor shall at all times minimise the adverse effect of dewatering required for the works to proceed. It will be the Contractor's responsibility to ensure that draw down outside the site does not exceed the limits shown on the Drawings or specified by the Engineer. The Contractor's method statement shall include details of measures proposed to meet this requirement. All such measures shall be subjected to the approval of the Engineer.

## **10.0 WATER PUMPED FROM CAISSONS**

Water sample pumped from caissons shall be screened through sedimentation or settling tank and quantities of the sediment shall be monitored to ensure that excessive fines are not removed from the surrounding soil. Should excessive fines be observed from any caisson, pumping from that caisson shall cease and the Engineer shall be notified immediately.

When required by the Engineer, the Contractor shall record the rate of pumping from the individual caissons and shall submit two copies of the records on the following day. The Contractor shall report immediately to the Engineer any marked change in the rate of flow of water from any caisson.

Water pumped from caissons or the ground shall not be discharged directly onto the ground surface without suitable provisions for drainage being made.

The Contractor shall be responsible for obtaining all necessary permissions from relevant authorities for discharging water into the public drainage system.

## **11.0 CESSATION OF EXCAVATION**

If the excavation and pumping from caissons results in settlement outside the site of more than 25mm, or as otherwise specified on the Drawings, caisson construction and dewatering at the appropriate locations shall immediately cease and the Engineer notified.

The contractor shall not recommence caisson construction or dewatering until the construction sequence has been reviewed and measures have been taken to prevent further settlement from occurring. In all cases, work shall not be resumed without the approval of the Engineer.

The Contractor shall be responsible for any damage, and any claims arising from such damage, which may result from settlement caused by caisson construction. The Contractor shall make good the damage as quickly as possible.

## **12.0 EMERGENCIES**

If the sides of a caisson start to collapse or an emergency arises which could lead to instability of the excavation, the Contractor shall immediately inform the Engineer and implement measures to preserve the stability of the caisson and of neighbouring structures and services.

## **13.0 DISPOSAL OF SPOILS**

Spoils removed from the excavation shall be removed from the site and disposed off in accordance with requirements of authorities.

## **14.0 PLACING OF CONCRETE**

All subsoil and debris shall be removed from the caisson to the satisfaction of the Engineer and shall not be allowed to re-enter into the hole during concreting of the caisson. No concrete shall be placed without the approval of the Engineer.

Each caisson shall be concreted in one continuous operation immediately after the excavation has been completed, inspected and approved. If the continuity of placing concrete is interrupted, no further concrete shall be placed until agreed by the Engineer.

At all times when concrete is being placed, a steel fixer shall be in continuous attendance to adjust and correct the position of any reinforcement which may be displaced.

Site mixed concrete shall be placed in its final position as soon as possible, and in no case more than half an hour after mixing. Ready-mixed concrete shall be placed within the agreed time after adding water and immediately when it leaves the mixing truck or agitator.

Concrete shall be placed by a method which ensures that the concrete is discharged at a level not higher than 3.0m above the surface of the concrete in the caisson.

In the event that the caisson cannot be kept completely free of water during concreting, the Engineer may direct that concrete be placed through water by means of one or more tremie pipes. Concrete shall be placed continuously and where two or more pipes are used in the same caisson simultaneously, care shall be taken to ensure that the concrete levels at each pipe position are maintained nearly equal.

Tremie pipes shall be clean, watertight and of adequate diameter to allow free flow of concrete. The tremie pipe shall extend to the bottom of the caisson prior to the commencement of concrete pouring and care should be taken to ensure that all water is expelled from the pipe during the initial charging process. After initial charging the tremie pipe shall be maintained with a minimum embedment of 1.0m into the concrete to prevent the re-entry of water into the pipe.

## **15.0 CONCRETED LEVELS**

For caissons concreted in the dry, the concreted level shall not be less than 500mm above the specified trimmed level. For caissons cast using tremie concrete, the concreted level shall not be less than 1m above the specified trimmed level.

This shall not relieve the Contractor of his responsibility to provide the specified quality of concrete at and below the trimmed level.

The Contractor shall trim back the concrete of all caissons to the final cut-off (trimmed) level. Trimming back shall be carried out not less than 7 days after placing the concrete.

## **16.0 REINFORCEMENT REQUIREMENT**

The minimum reinforcement requirements are shown on the Drawings.

## **17.0 PLACING REINFORCEMENT**

Reinforcement shall not be placed until it is inspected and accepted. Reinforcement cages shall be sufficiently long to ensure that they remain at their correct level during the placing of concrete. The minimum cover to all reinforcement shall not be less than 40mm or as otherwise specified in the Drawings.

The Contractor shall make provision for stiffening and strengthening reinforcement cages to allow them to be installed in the caisson without damage or deformation to their specified form. The Contractor shall make provision for suspending the reinforcement cage in the caisson correct to line and level.

Details of the means of ensuring the correct cover to and position of the reinforcement in the caisson shall be submitted for approval.

### **17.1 Protection of Reinforcement**

Reinforcement protruding above concreted level shall be protected by cement wash.

### **18.0 TOLERANCES**

The effective diameters of the caisson shaft and bell out shall not be less than those shown on the Drawings nor exceed the specified dimensions by more than 50mm.

The maximum permissible deviation at trimmed level of the center of each caisson from the correct center point is 75mm in any direction. The maximum permissible deviation from the vertical at any level of a caisson is 1 to 150.

The trimmed level of the caisson shall nowhere be higher than the designed cut-off level. The trimmed level shall not be below the cut-off level by more than 25mm.

The setting out of each caisson should be checked immediately after the first section of lining is cast.

### **19.0 BACKFILLING EMPTY EXCAVATION**

Every empty excavation shall be backfilled above concreted level to ground after concreting is completed.

The Contractor's proposals for backfilling empty excavation shall be included in the method statement submitted to the Engineer for approval before work commences. Where directed by the Engineer the empty excavation shall be backfilled with lean mix concrete to ground level.

### **20.0 RECORDS**

#### **20.1 Daily Records**

The Contractor shall keep daily record for each caisson as shown below.

Two signed copies of the record for each caisson shall be supplied to the Engineer on site on the day following the day to which the record relates:-

Information to be recorded:

- a) Date, time of execution for different types of work.
- b) Weather.
- c) Caisson number.
- d) Type of work carried out and equipment in use.
- e) Level of adjacent ground referred to Principal Datum.
- f) Level of survey markers on upper section of concrete lining referred to Principal Datum.
- g) Depth of caisson at end of day below adjacent ground level.
- h) Details and depth of each type of ground encountered.
- i) Description of soil and rocks encountered during excavation.
- j) Type and volume of concrete placed.
- k) Depth of caisson concreted.
- l) Level of any groundwater encountered.
- m) Number and position of pumps in operation, its rates and duration of pumping.
- n) Accurate record of bedrock proving test.
- o) Preliminary record of caisson base.
- p) All tests made on materials.

## **20.2 Complete Records**

The Contractor shall make a complete record of each caisson as shown below.

One set of records for each caisson shall be supplied to the Engineer on site within two weeks of completion of each phase of caisson construction.

- a) Caisson number.
- b) Level of top of concreted caisson shaft referred to Principal Datum.
- c) Level of top concrete lining referred to Principal Datum.
- d) Depth to base of caisson from top of concreted shaft.
- e) Date(s) and time(s) of starts and finishes of excavations and concreting.
- f) Minimum internal diameter of caisson lining.
- g) Full details of any bell-out and minimum diameter of caisson base.
- h) Thickness and details of concrete lining.
- i) Description of ground excavated and methods employed.
- j) Description of soil and rocks encountered during excavation.
- k) Sizes and types of reinforcement and details of reinforcement cage.
- l) Type and volume of concrete placed, measured in not more than 2.0m increments in level.
- m) Details of all obstructions, delays and other interruptions.
- n) Complete record of bedrock proving test.
- o) Final log and photographic record of caisson base.
- p) Results of core test.
- q) All tests made on materials used in the works.

On completion of caisson construction the Contractor shall submit to the Engineer as-built Drawings recording the concreted levels, trimmed levels and founding levels of all caissons together with their surveyed position at concreted level relative to the main building grid. The as-built Drawings shall be in soft and hard copy.

## **21.0 LOAD TESTS ON CONTRACT CAISSONS**

### **21.1 Instruction To Test**

The Contractor may be instructed to test load Contract Caissons in order to confirm that they meet the requirements of the Specification for load-deflection behaviour.

### **21.2 Selection of Caissons to be Tested**

The Engineer will select the caissons to be tested after their installation.

### **21.3 Arrangement for Loading**

Details of the proposed arrangement for test loading shall be submitted to the Engineer for approval before the installation of each test assembly. The required capacities and permitted arrangements are described in the Drawings and specification.

### **21.4 Notice of Commencement of Tests**

The Engineer shall be given at least 48 hours notice of the commence of each test.

## **21.5 Sequence of Test Loading**

The sequence of loading shall be as specified or directed by the Engineer.

## **21.6 Load Deflection Criteria**

Contract Caissons shall be deemed to comply with the requirements of the Specification if: -

- a) the cumulative residual settlement when the test load is removed at the end of one design load does not exceed 5mm unless otherwise stated by the Engineer.
- b) the settlement at the end of the period under Design Work Load does not exceed the permitted settlement of 12.0mm unless otherwise stated by the Engineer.

## **22.0 SAFETY PRECAUTIONS**

### **22.1 General**

The Contractor shall at all times comply with all the relevant regulations for safety on work sites. The working facilities provided and the manner in which the works are conducted shall conform to the requirements of BS 5573 : 1978. A copy of BS 5573 : 1978 shall be kept on site by the Contractor and shall be adhered to the following requirements. Where differences occur the more onerous requirement shall prevail.

Nothing mentioned herein shall in any way negate the Contractor's legal responsibilities either within the terms of this Contract or otherwise. Neither shall the fact that any specific item relating to the safety of workmen or other persons on the site has not been mentioned in this Specification relieve the Contractor of his responsibilities in that matter.

### **22.2 Electrical Equipment**

All electrical equipment shall be wired in accordance with 'Regulations for the Electrical Equipment of Buildings', 15<sup>th</sup> Edition, published by the Institution of Electrical Engineers. The equipment shall be tested every three months or at each new caisson position, whichever is the more frequent. In particular, a visible external Earth Continuity Conductor with an impedance of less than one ohm shall be provided.

### **22.3 Caisson Shafts**

The Contractor shall ensure that construction of the concrete caisson lining follows the excavation sufficiently close to ensure the stability of the works.

The Contractor shall ensure that the concrete caisson lining extends a minimum of 0.75m above and adjacent surrounding ground at all times.

The Contractor shall keep all caissons without activity covered at all times by a stout safety cover capable of supporting at least 3 personnel weight (total 300kg) and a uniformly distributed load of 3.0kN/m<sup>2</sup> and preventing entry of water into the caisson. The cover shall be attached rigidly to the top of the concrete lining to fully cover the caisson.

A barricade shall be constructed at the top of the caisson rig to prevent objects from falling into the hole.

If an access platform is provided at the top of the caisson hole through which access to the caisson is gained, it shall be equipped with a stout 150mm high kicker board around the full perimeter. The area adjacent to the kicker board shall be kept clear at all times of all loose rubble, tools or other objects which may be knocked into the caisson.

The Contractor shall at all times ensure that there is a hessian rope of minimum diameter of 20mm securely fixed at ground level and passing over a block on the frame above the caisson and reaching the bottom of the caisson.

#### **22.4 Ventilation**

The Contractor shall provide sufficient compressors, air pumps, etc. including an adequate number of standby spares, in order to ensure complete ventilation of all shafts whilst work is in progress and prevent the build-up of noxious gases or de-oxygenation.

Exhaust pipes from boring machines, winches and other equipment shall be so positioned such that no exhaust gas enters the caisson or the intake of the air compressors supplying the safety airline or the fresh air supply to the base of the caisson.

Smoking shall not be allowed in the caisson shafts.

#### **22.5 Lighting**

The Contractor shall maintain adequate artificial lighting at all times in all caisson shafts whilst work is in progress.

#### **22.6 Water in Caisson Shafts**

The Contractor shall provide pumps, including an adequate number of standby pumps, to ensure the safety of the works.

#### **22.7 Access and Communications**

The Contractor shall provide access to all levels of shafts at all times whilst work is in progress and a means of communication with workman in the shafts of a type that gives immediate notice to and from the surface of hazards which directly affect safety in the shaft.

#### **22.8 Removal of Persons from Caisson Shafts**

The Contractor shall provide a means whereby persons, including those semi-conscious or unconscious, may be removed rapidly and safely from caissons.

#### **22.9 Oxygen**

The Contractor shall provide at all times equipment and spares to enable oxygen to be administered to persons in an asphyxiated condition. The contractor shall ensure the permanent presence on site during hours of work of an operator fully trained in the use of this equipment during work hours.

#### **22.10 Facilities for Descent of Caissons**

##### **22.10.1 Supervisory Staff**

The Contractor shall ensure that a responsible person shall be in attendance at all time when inspection or testing is being carried out. The responsibility of this person shall be to supervise the lowering and hoisting of the staff or materials, to accept instructions from the person in the caisson, and to see that all necessary precautions are taken. He shall be

provided with lighting set of "sealed beam" type of sufficient power to adequately illuminate the bottom of the excavation. He shall not carry loose tools or other objects on him, which may fall into the excavation.

No other personnel shall be allowed near the top of the caisson except for a specified purpose connected with the inspection of the works. Any such personnel shall be under the supervision of the responsible person referred to above and shall comply with the same conditions regarding loose tools or other objects on him.

### **22.10.2 Cage**

Descent shall be by means of a steel cage of approved design with an approximately height of 1.8m. The upper sides of the cage shall be opened to allow inspection of the sides of the caisson.

The base of the cage shall be of sufficient weight to remain near vertical when carrying one person.

The cage shall be fitted with a two points suspension capable of sustaining a minimum upward force of 10 kN and preventing spinning of the cage. A certificate shall be provided showing that the system has been tested to this load within the previous six months.

The cage shall be provided with: -

- a) An air-line and mask or other satisfactory air supply.
- b) A safety helmet.
- c) A powerful battery operated light.
- d) A safety harness and line.
- e) Gas detector sensitive to the range of harmful gases described in BS 5573 : 1978.

### **22.10.2 Hoist**

The hoist for the cage shall be such that an electric motor powers the drum in both directions to allow a controlled descent. A "fail-safe" mechanism shall be fitted to the winding gear and the minimum capacity of the double-chain hoist shall be of one tonne force (10 kN/force). At A minimum of two hoist of this type shall be maintained on site at all times.

All lifting and safety equipment shall comply with BS 5573 : 1978.

The frame supporting the cable shall be designed to place the minimum surcharge on the ground near the top of the excavation and shall be stable under the full winding capacity of the hoist.

There shall be a Hessian rope of minimum diameter 20mm securely fixed at ground level passing over a block on the frame and reaching to the bottom of the caisson at all times.

No one may enter or leave the caisson while others are working in the caisson.

Workers should stand under a protective temporary shed during lowering or lifting of hoist bucket.

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