



TRANSNET SOC LTD

**DCT BERTHS 203 TO 205 - RECONSTRUCTION, DEEPENING AND
LENGTHENING**

PORT OF DURBAN

SPECIFICATION – CAISSON CONSTRUCTION AND PLACEMENT

1785-CO-000-C-SPC-0002 Rev T-02

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1.0 SCOPE

1.1 Project

This specification is a project specific technical specification for the DCT Berths 203 to 205 Reconstruction, Deepening and Lengthening Project in the Port of Durban.

1.2 Scope

The scope of this specification covers the *Employer's* requirements for the construction of concrete caissons and their placement in a marine environment. It covers Materials, Equipment, quality, manufacture, construction, testing and tolerances.

Construction of the new Berths 203 to 205 utilises precast concrete caissons, which shall be cast and transported to the site where they shall be sunk on a prepared foundation bed.

This specification covers:

- a) Manufacturing of caissons
 - Establishment and maintenance of caisson casting yard.
 - Casting of caisson bases and slip forming caisson walls.
- b) Caisson transit
 - Lot 10 Launching dock deepening.
 - Installation and commissioning of Synchrolift.
 - Caisson launching.
 - Caisson towing.
 - Caisson positioning.
- c) Caissons Quay Wall joints, seals and backfill
 - Stone fill between caissons.
 - Joints and grouting.
 - Sand-fill and reclamation are covered only in relation to construction sequencing. Material, construction and performance specifications for the filling and vibro-compaction are provided in specification 1785-CO-000-C-SPC-0004 – Dredging and Reclamation (Including Vibro Compaction).
- d) Manufacturing, lifting, loading and positioning of precast infill panels.

2.0 NORMATIVE REFERENCES

2.1 Reference Documents

The *works* shall be carried out as specified in the following documents:

- a) This Specification.
- b) The Industry Codes, Standard Specifications listed in Section 2.2.
- c) The *Employer's* Project Specific Technical Specifications listed in Section 2.3.
- d) The *Project Drawings*, including the 1785-CO-060 series thereof concerning the Caisson Quay Wall.

2.2 Standard Specifications

The *Contractor* shall provide and maintain current copies of all the standard specifications referred to herein below on the site for reference by both parties.

2.2.1 Caisson and infill panel manufacturing

Construction of the caissons and infill panels shall comply with the following standard specifications:

- a) ACI 313-97 – Standard Practice for Design and Construction of Concrete Silos and Stacking Tubes.
- b) SANS 2001-CC1:2012 – Concrete works (structural).
- c) SANS 2001-CC1:2007 – Concrete works (structural).
- d) ASTM C-923: 'Standard specification for resilient connectors between reinforced concrete manhole structures, pipes and laterals'.

- e) SANS 2001-CS1:2012 – Structural Steel Work.
- f) SANS 121:2011/ISO 1461:2009– Hot-dip (galvanized) Coatings on fabricated iron and steel articles.

2.2.2 Caisson launching, towing and positioning

Launching, towing and positioning of the caissons shall comply with the following standard specifications:

- a) DNV-OS-C502 – Offshore Concrete Structures, September 2012.
- b) DNV-OS-H101 – Marine Operations, General.
- c) DNV-OS-H102 – Marine Operations, Designed Fabrication, January 2012.
- d) DNV-OS-H201 – Load Transfer Operations, April 2012 (for launching of caissons using the synchrolift).
- e) DNV-OS-H202 – Sea Transport Operations, October 2015, VMO Standard Part 2-2 (for towing of caissons).
- f) DNV-OS-H203 – Transit and Positioning of Offshore Units, February 2012.
- g) DNV-OS-H204 – Offshore Installation Operations, November 2013, VMO Standard Part 2-4 (for positioning of the caissons).

2.2.3 Infill panel loading, transfer and positioning

Loading, transfer and positioning of infill panels shall comply with the following standard specifications:

- a) DNV-OS-H101 – Marine Operations, General.
- b) DNV-OS-H102 – Marine Operations, Designed Fabrication, January 2012.
- c) DNV-OS-H201 – Load Transfer Operations (for load out).
- d) DNV-OS-H202 – Sea Transport Operations, VMO Standard – Part 2-2 (for towing of barge).
- e) DNV-OS-H205 – Lifting Operations (VMO Rules Part 2-5) for lifting and placement of the infill panels, April 2014.
- f) International Maritime Organization, International Code on Intact Stability, 2008.
- g) International Maritime Organization (IMO), International Code of Safety for High Speed Craft 2000, 2008 Edition, Annexure 8.
- h) Bureau Veritas, Towing at Sea of Vessels or Floating Units, NR183, 1986.
- i) DNV-RP-H101 – Risk Management in Marine and Subsea Operations, January 2003.
- j) DNV-RP-H103 – Modeling and Analysis of Marine Operations, February 2014
- k) DNV-RP-H104 – Ballast, Stability and Watertight Integrity-Planning and Operating Guidance, September 2011.

2.2.4 Caisson quay wall joints and seals

Quay wall joints and seals between caissons shall comply with the following standard specifications:

- a) BS 812 – British Standards Institution – Method for sampling and testing mineral aggregates (or equivalent BS EN revision).
- b) CIRIA, C683 – The Rock Manual, The use of rock in hydraulic engineering (2nd Edition), 2007, Revised August 2008.
- c) BS EN 13251:2014 +A1:2015 – Geotextiles and geotextile-related products. Characteristics required for use in earthworks, foundations and retaining structures.
- d) BS EN 446:2007 – Grout for prestressing tendons – Grouting procedures.
- e) BS EN 447:2007 – Grout for prestressing tendons – Basic requirements.

2.3 Employer's Project Specific Specifications and Standards

Caisson construction and placement shall also comply with the following Project Specific Specifications and Standards:

- a) 1785-CO-000-C-SPC-0001 – Concrete for Marine Construction.
- b) 1785-CO-000-C-SPC-0004 – Dredging and Reclamation (Including Vibro Compaction).
- c) 1785-CO-000-C-SPC-0010 – Ground Improvement: Rigid Inclusions and Foundation Stone Bed (Caisson Load Transfer Platform).
- d) Project Environmental Specifications (PES) as contained in the Works Information and annexures.

3.0 DEFINITIONS

All definitions of responsibilities shall be in accordance with the NEC Engineering and Construction Contract (ECC) for the construction of the *works*.

Where the standard specifications referenced in this specification refer to the “Engineer”, replace this term with the term “*Supervisor*”.

For the purpose of this specification, the technical definitions and abbreviations given in SANS 2001, together with the following additional definitions, shall apply:

3.1 Chart Datum Port

Chart Datum Port refers to the reference level used in the Port of Durban, which is 0,900 m below Mean Sea Level. All levels referred to in this document are relative to Chart Datum Port (CDP).

3.2 Co-ordinate System

The co-ordinate system to be used for all setting out and survey shall be World Geodetic System 1984 (WGS84), L031, referred to as WG31.

3.3 Tidal Levels

The Astronomical Tide Predictions as defined by the SA Navy Hydrographer and Chart SAN 2006 are as follows:

Table 3.1 – Tide Data

Tide	Abbreviation	Level m, Chart Datum Port
Highest Astronomical Tide	HAT	2.287
Mean High Water Springs	MHWS	1.997
Mean Level	ML	1.097
Mean Low Water Springs	MLWS	0.197
Lowest Astronomical Tide	LAT	-0.013

3.4 Method Statements

Method Statements shall be compiled by the *Contractor* for all activities entailed in the construction, movement and placement of the caissons in accordance with the Contract, and submitted to the *Supervisor* three weeks in advance of commencement of the activities referred to therein, including full details of all proposed equipment, temporary works and methods. No activity shall commence until the method statements has been accepted (accepted with comments) by the *Supervisor* and *Project Manager*.

Further details of the requirements of particular method statements are provided in sections 4.0 to 7.0.

3.5 Foundation Stone Bed (Load transfer Platform)

The term “foundation stone bed” refers to the layer of stone placed above the ground reinforced with rigid inclusions. This layer, which is also known as the “load transfer platform (LTP)” forms the platform on which the quay wall structure is placed. This layer is composed of compacted stone with geotextile reinforcement at its base.

3.6 Geotextile Reinforcement

This term refers to the geotextile placed at the base of the foundation stone bed.

3.7 Slip-forming

The term ‘Slip-forming’ (also referred to as ‘Sliding’) refers to the process of constructing a vertical structure using a continuously moving form.

3.8 Steel Fiber Reinforced Concrete (SFRC)

This term refers to concrete with steel fibres added to the concrete mix.

4.0 CAISSON AND INFILL PANEL MANUFACTURING INCLUDING CASTING YARD ESTABLISHMENT

4.1 Method Statements

Method statements for this section shall include:

4.1.1 Establishment of Lot 10 casting yard

- a) Layout of Lot 10 including space requirements for batch plant, caisson casting yard and precast item casting yard.
- b) Details of establishment at casting yard including details of planned renovations/amendments to existing casting beds and transfer beams.
- c) Batch plant layout.
- d) Details of provisions for concrete supply for 24 hour slip forming operation (including provision for concrete supply in the event of site batch plant breakdown).

4.1.2 Caisson manufacture

- a) Details of concrete mix designs in accordance with specification 1785-CO-000-C-SPC-0001 – Concrete in Marine Environment.
- b) Detailed design and drawings of:
 - Caisson jacking and skidding system for caisson transfer.
 - Slipform system for caisson wall casting.
 - Synchrolift.
- c) Proposed schedule for caisson manufacture including production rates for casting of bases and slip forming of walls.
- d) Details of shift work making allowance for overlapping of shifts for handover.
- e) Emergency procedures for dealing with breakdowns, power failures etc. to ensure that the slip form operation is not halted.
- f) Full methodology for casting, jacking, transferring the caissons to the launching dock and launching caissons.
- g) Overall schedule for caisson manufacturing taking into account phased nature of work and limited space available for storage of caissons.
- h) Proposals for manufacturing and transporting of special caissons and caisson infill panels.

4.2 Materials

4.2.1 Reinforced concrete

- 4.2.1.1 All materials for concrete works for the caissons and infill panels shall be in accordance with *Employer* Specification 1785-CO-000-C-SPC -0001 – Concrete for Marine Construction.

4.2.2 Flexible pipe connector

- 4.2.2.1 The flexible pipe connector gasket cast into the caisson walls shall be in accordance with ASTM C-923: 'Standard specification for resilient connectors between reinforced concrete manhole structures, pipes and laterals'.

4.3 Equipment (Including Temporary Works)

4.3.1 General

- 4.3.1.1 The *Contractor* shall provide all the Equipment required to provide the Works associated with the caisson and infill panel manufacturing which shall include:
 - a) Concrete batch plant(s).
 - b) Tower and mobile cranes.
 - c) Scaffolding and specialized equipment for working at height.
 - d) Forms for caisson bases.
 - e) Equipment for Slip-forming caisson walls.
 - f) Temporary works for Caisson manufacture and transfer including casting beds, jacking beams and transfer beams.

- g) Jacking and rigging Equipment for caisson transfer.
 - h) Props to Lot 10 Launching Dock.
 - i) Navigation lighting for stored caissons.
 - j) Adequate power supply as well as stand by generators such that the casting and handling of the caissons will not be interrupted by potential power failures.
 - k) Lighting for night operations.
- 4.3.1.2 All lifting and rigging Equipment shall comply with the OHS Act and be provided with current test certificates. The *Contractor* shall procure the services of a Registered Professional Engineer to design and sign off all Equipment including the slip-form system, jacking and transfer beams, jacks and any associated jacking stools, chairs or beams; and shall submit these designs for acceptance to the *Supervisor*.
- 4.3.2 Concrete Batch Plant**
- 4.3.2.1 The general requirements for the concrete batch plant are detailed in specification 1785-CO-000-C-SPC-0001 Concrete for Marine Construction.
- 4.3.2.2 The fine and course aggregate storage bins shall have a minimum stockpile/storage capacity for 2 weeks supply.
- 4.3.2.3 The cement storage silos shall have a minimum storage capacity for 2 weeks supply.
- 4.3.2.4 A standby batch plant shall be available in the event of breakdown of the main batch plant.
- 4.3.3 Caisson casting yard**
- 4.3.3.1 The *Employer* shall make available the old Lot 10 Casting Yard at the Bayhead for production of Caissons. This is an existing facility located at the Bayhead off Hamburg Road in the Port of Durban which was developed some years ago for the purpose of caisson construction for the extension of the Point area quay. It has not been used for several years and requires significant clearing, refurbishment and re-equipping to refit it for its purpose. At present the site is overgrown and it has been used as a dumping ground and storage space.
- 4.3.3.2 Details of the existing infrastructure at Lot 10 including an assessment of the condition of the previous casting infrastructure are provided in report “Lot 10 Casting Yard – Condition Survey” included in Part C4.1 Site Information. Drawings showing the layout, sections and details of the casting yard and launching dock as used by the previous contractor are provided in the annexures to the report.
- 4.3.3.3 The *Contractor* shall remove all vegetation, spoil material, debris, rubble, equipment and miscellaneous material on Lot 10 and dispose of the same, howsoever he may legitimately do, to make space available for the establishment of the batching plant and the casting yards.
- 4.3.3.4 The *Contractor* shall undertake a condition survey of the existing casting beds and transfer beams and undertake repairs, alterations or additions to the beams and beds as required.
- 4.3.4 Forms for caisson base manufacture**
- 4.3.4.1 The provisions relating to formwork of Specification 1785-CO-000-C-SPC-0001 – Concrete for Marine Construction shall apply.
- 4.3.4.2 The *Contractor* shall provide a bottom formwork panel to fill the gap in the casting bases under the caisson and transfer the load from the caisson to the jacks.
- 4.3.5 Slip-form**
- 4.3.5.1 The provisions relating to formwork of Specification 1785-CO-000-C-SPC-0001 – Concrete for Marine Construction shall in general apply to the Slip-form. In addition, the construction requirements listed in Chapter 3 of ACI 313-97 – Standard Practices for Design and Construction of Concrete Silos and Stacking Tubes shall also apply.
- 4.3.5.2 The Slip-form shall be robust so that it can be stripped and reassembled with ease to the original dimensions.

- 4.3.5.3 Forms shall be tight and rigid to maintain the finished concrete wall thickness within the specified dimensional tolerances.
- 4.3.5.4 The formwork shall be supported on a number of jacking yokes of the *Contractor's* design. The formwork shall be raised on jacking rods placed inside pipe formers and lifted by hand-over-hand hydraulic jacks.
- 4.3.5.5 The jacks shall be controlled by a central power pack capable of raising the whole formwork structure simultaneously and evenly as well as being capable of regulating the movement of each jack individually to correct for verticality.
- 4.3.5.6 Slip-form systems must be capable of adjusting the rate of slipping to suit the reinforcing and concreting operations.
- 4.3.5.7 An upper working platform shall be provided to fix reinforcing, place concrete and storage of Materials to be cast in. The platform shall be equipped with guardrails, toeboards and ladders and other such safety measures in accordance with Health and Safety requirements for working at heights.
- 4.3.5.8 Internal and external hanging platforms shall be provided for rendering the exposed concrete surfaces.
- 4.3.5.9 Lasers are to be used for verticality checking.
- 4.3.5.10 Sufficient and safe access shall be provided to the Slip-form platforms.

4.3.6 Caisson transfer (jacking and skidding) Equipment

- 4.3.6.1 The *Contractor* shall provide the following Equipment for the caisson transfer:
 - a) Sets of jacks which are to be set up in the two slots in the casting bases, capable of raising the caisson base, weighing an estimated 1155 tonnes plus 20 % safety margin.
 - b) Transverse travel mechanisms to transfer the caisson base once cast and to lower it onto the intermediate beams.
 - c) Sets of jacks to be set up adjacent to the intermediate beams, capable of raising the complete caisson, weighing an estimated 2360 tonnes plus 20 % safety margin.
 - d) Transverse travel mechanisms to transfer the complete caisson and to lower it onto the launching beams.
 - e) All localised, fixed and moveable diesel-powered hydraulic power packs and jacks to control lifting and transverse/longitudinal motions.
 - f) Long travel mechanism to raise the completed caisson and transfer it in stages to the Synchronlift platform.

4.4 Methods and Procedures

4.4.1 Caisson manufacturing

- 4.4.1.1 The *Contractor* shall make use of the existing casting facilities for the manufacturing of the caissons. The caissons have been designed such that they fit within the existing facilities and jacking and skidding points have been aligned with the existing facilities. The existing facilities make allowance for the simultaneous production of six caisson bases and six caisson walls.
- 4.4.1.2 Caisson bases shall be cast on the outer ends of the side transverse beams on concrete casting platforms. A total of six bases can be in production simultaneously. The slots in the bases require separate soffit formwork which shall form part of the transverse jacking system. In order to prevent adhesion between the bases and the casting platform, the bases shall be cast on plastic sheeting.
- 4.4.1.3 The caisson bases shall not be jacked or moved off the caisson base casting bed prior to the concrete achieving a minimum strength of 27 MPa. The *Contractor* shall determine the jacking layout, number of jacks and size of bearing plates such that the jacking/bearing pressure on the concrete base for this operation is limited to 3.5 MPa. The jacks shall be positioned in the existing transverse beam slots. Once the required concrete strengths have been achieved, the partly completed caisson base shall be jacked off the casting base, moved to the inner position and lowered onto the transverse beams. This allows the jacking equipment to be withdrawn and re-positioned for the next base to be cast.

- 4.4.1.4 The caisson walls shall be cast using a slip-form method of construction which shall continue on a 24/7 basis. This shall be a continuous process in which the reinforcement is fitted at the same time as the formwork climbs and wet concrete is mixed with wet concrete. The *Contractor* shall propose methods for concrete placement by crane and bucket or by pumping. The concrete mix design shall take account of both the method of placement, (which could require plasticizers) and the requirement for the concrete to have sufficient stiffness as it emerges from the sliding formwork during jacking. The setting rate of the concrete shall be constantly monitored to match the speed of the slip. The concrete shall be in accordance with specification 1785-CO-000-C-SPC-0001 – Concrete for Marine Construction. From the suspended platforms directly below the formwork, the concrete surface that appears under the formwork shall be smoothed and brushed before the concrete hardens.
- 4.4.1.5 Openings and embedded items shall be accommodated in accordance with the drawings. Certain caissons require an opening for the storm water pipe – the gasket for the pipe connection shall be cast-in during the slip form process.
- 4.4.1.6 Construction joints in the caisson walls are not be permitted.
- 4.4.1.7 The complete caissons shall not be jacked, moved or transferred to the longitudinal beams prior to the concrete in the base achieving its full design strength and the concrete from the last pour for the caisson walls achieving a minimum strength of 18 MPa. The *Contractor* shall determine the jacking layout, number of jacks and size of bearing plates such that the jacking pressure on the concrete base for this operation is limited to 7.5 MPa. Once the required concrete strengths have been achieved, caissons are sequentially transferred to the longitudinal launching beams, where further curing shall take place.
- 4.4.1.8 Cured caissons shall be moved by skidding and jacking equipment down the centre longitudinal launching beam to the launching dock. Horizontal jacking/skidding forces are to be applied to the jacks or skids themselves and not to the caisson.
- 4.4.1.9 Jacking rods required during the slip forming of the caisson walls are to be removed after completion of casting and the holes for the rods are to be grouted up with a cementitious, non-shrink grout with a minimum compressive strength of 50 MPa.
- 4.4.1.10 The *Contractor* to temporarily seal all openings including storm water pipe openings prior to launching caisson. Temporary seals to be designed to resist water pressure during launching and towing.
- 4.4.1.11 The caissons shall not be launched into the water prior to concrete surrounding the proposed towing attachment points achieving its full design strength and the concrete from the last pour for the caisson walls achieving a minimum strength of 32 MPa.
- 4.4.1.12 The *Contractor* shall employ specialist personnel with extensive experience in heavy lifts for the purposes of lifting, moving and launching the caissons.
- 4.4.1.13 The *Contractor* shall plan the setting up of the casting yard and its production capability to ensure the following:
- a) Special caissons and infill panels required for corners and transitions are produced in time
 - b) Standard caissons are constructed, cured and ready for launch at a suitable rate to meet his full construction program for Phase 1 at Berth 205.
 - c) Excess stock caissons shall be towed to the dedicated storage area located in the basin adjacent to the sandbank opposite Berths 205 to 203. The caissons shall be temporarily ballasted onto the seabed clear of the scour protection at the toe of the deepened basin after dredging to -16.5 m. All stored caissons are to be ballasted onto a level even bed and marked with lights and navigation marks in accordance with IALA and TNPA's requirements.
 - d) For the later phases, the *Contractor* may then at his option:
 - Suspend operations at the Casting Yard until production is necessary for Phase 2 at Berth 204 and subsequently for Phase 3 at Berth 203; or
 - Continue with caisson production and store the finished caissons by sinking them in the dedicated storage area in accordance with the above requirements.

5.0 CAISSON LAUNCHING, TOWING AND POSITIONING

5.1 Method Statement

The method statements for this section shall include *inter alia*:

- a) Methodology for installing props required for launching dock deepening.
- b) Detailed design and drawings of the Synchrolift.
- c) Detailed methodology for installing Synchrolift.
- d) Synchrolift commissioning and operating procedures including emergency procedures.
- e) Detailed stability and hydrodynamic study for caisson towing to determine optimum towing layouts, distances and speed.
- f) Limiting wave and wind conditions for caisson towing.
- g) Forecasting system to ensure caisson is not towed during adverse wind and wave conditions.
- h) Procedures for launching, turning and towing caissons, including emergency procedures.
- i) Schedule for launching and towing of caissons taking into account limitation of launching on rising tide above MSL.
- j) Procedures for checking caisson draft and for ballasting or additional buoyancy in the event of significant listing.
- k) Details of towing equipment including tugs, barges, towing bridles, tow ropes, tailing ropes, emergency anchors and caisson attachment points.
- l) Details of ballasting for sinking of caissons.
- m) Methodology for refloating caissons.
- n) Methodology for placing of caisson within required tolerances taking into account effects of aquaplaning/skating as base approaches seabed.

5.2 Materials

5.2.1 Structural steel

- 5.2.1.1 The structural steel for the Lot 10 launching dock props shall be Grade 350W to SANS 1431.
- 5.2.1.2 Galvanising shall be carried out in accordance with SANS ISO 1461. The coating thicknesses shall be 25% greater than the standard table 2, in accordance with SANS Specific Permit Conditions 1336/2494.

5.3 Equipment (Including Temporary Works)

5.3.1 General

- 5.3.1.1 The *Contractor* shall provide all the Equipment required for launching, towing and positioning of the caisson which shall include *inter alia*:
 - Synchrolift for caisson launching.
 - Marine Equipment for caisson towing.
 - Marine Equipment for caisson placement and refloating.
- 5.3.1.2 The *Contractor* shall procure the services of a Registered Professional Engineer and Naval Architect to design and sign off all Equipment for the launching, towing and positioning of the caissons and shall submit these designs to the *Supervisor* for acceptance.

5.3.2 Launching Equipment (Synchrolift)

- 5.3.2.1 The *Contractor* shall design, procure, deliver, install, commission and maintain the Synchrolift required for the caisson launching.
- 5.3.2.2 The launching Equipment shall comply with the requirements of Section 4 of DNV-OS-H201.
- 5.3.2.3 The synchrolift platform shall be lifted and lowered using a set of hydraulic strand jacks supported on the two existing upstand concrete lifting beams.
- 5.3.2.4 The strand jacks shall be provided with full instrumentation, load sensing mechanisms and a position holding and adjusting system that shall maintain the platform of the synchrolift at exactly the same level, to a tolerance of < 5 mm over the long dimension of the caisson, while the load is transferred sequentially from the long travel system to the synchrolift.

5.3.2.5 The synchrolift shall be capable of lowering the caisson into the water, while retaining its level to the above tolerance.

5.3.2.6 The *Contractor* shall maintain ownership and responsibility for operating the Synchrolift for the duration of the Contract. Upon Completion of the *works*, the Contactor shall decommission the Synchrolift and remove it from site.

5.3.3 Towing Equipment

5.3.3.1 The *Contractor* shall provide the following Equipment for the towing of caissons:

- A sufficient number of suitable vessels with qualified marine crew to tow and steer the caisson ensuring the caisson does not deviate off the specified tow path even in high winds.
- Towing bridles, tow ropes, tailing ropes and an emergency anchor.
- Emergency towing arrangements.
- A portable pump system capable of removing rainwater or leakage and to avoid the instability resulting from free surface effects.
- Navigation lighting for stored caissons.

5.3.3.2 All Equipment shall be sized and designed in accordance with the requirements of DNV-OS-H202.

5.3.3.3 The emergency towing arrangement shall consist of a single spare towing connection located at the aft end of the caisson relative to the direction of tow, attached at an approved location. A pennant shall be connected to the connection and led aft to a floating line. The pennant and towing connections shall be sized similarly to the main towing equipment.

5.3.3.4 All marine equipment used shall be subject to the requirements and approval of the South African Maritime Safety Association (SAMSA).

5.3.3.5 *Contractor's* floating equipment shall be maintained in a satisfactory and seaworthy condition, shall have adequate attendance by competent seamen at all times, shall be fully provided with sound and satisfactory ropes, line and moorings and shall be fully equipped with lights.

5.3.3.6 At all times the *Contractor* shall be wholly responsible for the protection and safety of all floating craft engaged by him.

5.3.3.7 The *Contractor* shall immediately and at his own cost re-float or raise and remove any *Contractor's* Equipment (floating or otherwise), vessel, craft or Materials (including the caisson itself) or any other property in his care or belonging to him or to any Subcontractor, which may be stranded or sunk in the course of execution and completion of the works. Until such sunken object is raised and removed the *Contractor* at his own cost shall set buoys and display such lights and do all such things for the safety of navigation as may be required by the authorities concerned or by the *Supervisor*.

5.4 Methods and Procedures

5.4.1 Launching Dock Deepening

5.4.1.1 The caissons shall be launched into the water at the existing Lot 10 launching dock. Prior to installing the Synchrolift, the *Contractor* shall dredge the launching dock to provide sufficient depth for the launching and towing of the caissons. The launching dock is to be dredged to a level of -12.62 m CD to create sufficient draft for the installation of the Synchrolift and for the launching of the caissons. Props and toe piles are to be installed at the launching dock to ensure the existing sheet pile walls remain stable at this dredged depth. Details of the props and piles are shown on drawings 1785-CO-020-C-DWG-0011 Sheets 1 to 3. The dredging of the launching dock is covered in specification 1785-CO-000-C-SPC-0004 Dredging and Reclamation (Including Vibro Compaction).

5.4.2 Launching and Towing

5.4.2.1 The launching operation shall be planned and undertaken in accordance with DNV-OS-H201 with particular reference to Section 4.

5.4.2.2 The towing operation shall be undertaken in accordance with DNV-OS-H202 with particular reference to Sections 4 and 5.5.

- 5.4.2.3 The *Contractor* shall be responsible for undertaking stability and hydrodynamic studies of the caissons to determine safe and optimal towing procedures, Equipment, and speeds.
- 5.4.2.4 The *Contractor* shall ensure that in his method for towing, setting down and refloating of caissons a metacentric height of greater than 0.4 m is maintained at all times.
- 5.4.2.5 The *Contractor* shall ensure that during towage of the caissons that the dynamic stability is maintained such that resonance responses (in any of the six rigid body motions) do not occur.
- 5.4.2.6 Attachment points for the towing of the caisson are shown on the drawing and are to be cast in during caisson manufacture. The *Contractor* is responsible for selecting the type and size of attachment and shall inform the *Supervisor* of the proposed attachment for incorporation in the design of the caisson.
- 5.4.2.7 Prior to launching of the caissons, the *Contractor* shall seal all openings including towing attachment points. The temporary seals to openings are to be designed to resist all static and hydrodynamic forces during launching and towing.
- 5.4.2.8 The entire launching and towing operation shall be done in close co-operation with the Harbour Master.
- 5.4.2.9 For launching, the caisson shall be moved onto the synchrolift platform, which shall be carefully controlled to compensate for the load and remain level while the caisson is lowered into the water until it floats.
- 5.4.2.10 The anticipated draft of the typical Type 1 caissons while floating is 11.6 m, while the launching dock will have a depth of only -11 m CDP with the Synchrolift lowered. The *Contractor* shall therefore launch during a rising tide with tide level > 1.4m to ensure sufficient clearance between the caisson bottom and the Synchrolift platform, allowing for the depth of the synchrolift platform itself. Tides are to be strictly monitored using either tide gauges installed by the *Contractor* or using the port's tide gauges. The *Contractor* shall check the draft at four points immediately after launching. If there is any significant list (> 2.5 degrees), the *Contractor* shall ballast the caisson or provide additional buoyancy to bring the caisson to an even draft.
- 5.4.2.11 The *Contractor* is made aware that certain of the caisson special types are not symmetrical and the *Contractor* shall make provisions for additional buoyancy or ballasting to account for eccentricities.
- 5.4.2.12 Floating out of the caisson from the launching dock shall be undertaken in a controlled manner at sufficiently low towing speeds to ensure that the caisson does not list within the dock. Sudden accelerations during pull off and towing shall be avoided.
- 5.4.2.13 Once the caisson has been floated out of the launching dock, the caisson shall be rotated 90 degrees such that the toes of the caisson base are perpendicular to the line of towing. The caisson shall be towed on a rising tide to the Maydon Wharf Channel (dredged to -12.2 m CDP) and down the Esplanade Channel to the Berth 203 – 205 basin. This shall be accomplished without grounding in the main navigation channels or basin.
- 5.4.2.14 The *Contractor* shall ensure that no appreciable change to list or particularly fore and aft trim occurs that could result in the toe of the caisson making contact with the floor of the channel. Wind generated waves and the effects of wind on towing operations are to be taken into account to maintain adequate safe clearances while towing the caissons. Lights and navigation beacons shall be provided on the caissons during towing.
- 5.4.2.15 It shall be permissible to ground and store the caissons in the channel just outside the launching dock to await suitable conditions for towing, provided the *Contractor* has ensured that the dredged channel is even and level and no obstructions could damage the caisson or result in it settling unevenly and that the caisson is sufficiently ballasted to prevent it from re-floating and drifting uncontrolled. A maximum of 3 caissons shall be stored in this area at any one time. Should the *Contractor* elect to store a caisson in this area, the *Contractor* shall provide lights and buoys attached to the caisson to demarcate the caisson to the satisfaction of the Harbour Master.

- 5.4.2.16 Once the caisson has been towed into the Maydon Wharf channel, the remainder of the towing procedure to the construction site or to the demarcated temporary storage area adjacent to Pier 2 shall be undertaken in a single continuous operation as no storage of caissons shall be permitted within the main navigation channels.
- 5.4.2.17 Should the *Contractor* fail to meet the foregoing obligations the *Employer* may buoy and light each sunken object and re-float or raise and remove the same (without prejudice to the right of the *Employer* to hold the *Contractor* liable) and the *Employer* shall be entitled to recover from the *Contractor* the cost thereof or may deduct the same from any monies due or that become due to the *Contractor*.
- 5.4.2.18 The channels along the tow route will be dredged by the *Employer* to -12.2 CDP at the Contract Date. Thereafter, it is the *Contractor's* responsibility to conduct ongoing bathymetric surveys of the tow route to determine if any siltation causing high spots have occurred that may affect the towing of the caissons. The *Contractor* shall be responsible for maintaining the dredged depth of the tow route until all caisson towing for the project has been completed.

5.4.3 Positioning of caissons

- 5.4.3.1 The positioning operation shall be planned and undertaken in accordance with DNV-OS-H204 with particular reference to Section 5.
- 5.4.3.2 The foundation stone bed under the caisson shall be signed off in respect of evenness of bed and level (refer to specification 1785-CO-000-C-SPC-0010) prior to placing of the caisson. The *Contractor* shall conduct a final dive inspection of the bed to ensure it is clean and there is no build-up of silt or other detritus. All silt material shall be removed via an airlift operation.
- 5.4.3.3 Prior to positioning the caisson, all drain pipes, mating faces and in particular recesses for grout socks are to be clean and free of barnacles or marine growth.
- 5.4.3.4 Prior to lowering, caissons shall be towed to their final positions in plan and located accurately in respect of orientation, line and gap between them and their adjacent units (Nominal gap 60 mm \pm 50 mm). The *Contractor* shall provide adequate mooring and control mechanisms for this purpose, allowing for tidal currents and wind.
- 5.4.3.5 The *Contractor* shall sink the caisson slowly and evenly to its required grounded position by pumping sea water into it. The *Contractor* is made aware that based on experience from previous projects, the caissons have a tendency to aquaplane/skate in the transverse directions as the base approaches the stone bed due to the effect of water trapped between the base and the stone bed. The *Contractor* shall plan the grounding methodology and provide suitable holding and mooring equipment accordingly to deal with this and shall ensure the bases are placed within tolerance.
- 5.4.3.6 The *Contractor* shall check the tolerance of placement as soon as it has reached the bed and if satisfactory fill it completely with water.
- 5.4.3.7 If it is out of tolerance, water shall be pumped out and the caisson correctly positioned.

6.0 CAISSONS QUAY WALL JOINTS, SEALS AND BACKFILL

6.1 Method Statement

The method statements for this section shall include inter alia:

- a) Detailed installation methodology for installation of seals, grouting and filter fabric.

6.2 Materials

6.2.1 Geotextile filter fabric/separation layer

- 6.2.1.1 A geotextile is to be placed between the sand backfill and rock fill to prevent the intermixing of the two layers and at the caisson and capping beam joints. This shall be a nonwoven, needle punched, continuous filament, polyester geotextile. The geotextile shall conform to the properties given in Table 6.1.

Table 6.1: Required Properties of Separation Geotextile

Product:	Nonwoven, needle punched, continuous filament, polyester geotextile			
Intended use	For separation and filtration, in construction of earthworks, foundations and retaining structures.			
Tensile Strength (200 mm wide strip)	In weaker direction	kN/m	26*	BS EN 13251 EN ISO 10319
Elongation at maximum load	In weaker direction	%	50-70	BS EN 13251 EN ISO 10319
Resistance to static puncture	CBR test	kN	4.8*	BS EN 13251 EN ISO 12236
Dynamic perforation resistance	Diameter of hole (max)	mm	13*	BS EN 13251 EN ISO 13433
Water permeability	Normal to the plane	l/m ² s	70*	BS EN 13251 EN ISO 11058
Characteristic opening size	O _{95W}	µm	130*	BS EN 13251 EN ISO 12956
Durability	In accordance with the relevant clause of EN 13251, Annex B for service lives up to 50 years	-	-	BS EN 13251 Annex B

* Mean value – Manufacture shall provide tolerance values corresponding to the 95% confidence level.

- 6.2.1.2 The geotextiles shall be manufactured under a quality management system that is third party certified to ISO 9001:2000 standards.
- 6.2.1.3 Geotextile filaments shall be rot-proof and chemically stable. Filaments shall resist delamination and maintain their relative dimensional stability in the geotextile.
- 6.2.1.4 The *Contractor* shall submit to the *Supervisor* certified test results and statements of quality that show without exception that the proposed geotextiles meet the requirements of this specification.
- 6.2.1.5 Geotextiles shall not be exposed to temperatures in excess of those recommended by the manufacturer. Outdoor storage shall not be for periods that exceed the manufacturer's recommendations. Geotextiles shall not be exposed to direct sunlight prior to installation for more than 14 days.
- 6.2.1.6 On site quality control shall be in accordance with PD CEN/TR 15019.
- 6.2.2 Grout socks**
 - 6.2.2.1 Grout socks shall be specially formulated geo-socks used as a grout retainer to prevent loss of grout. The grout sock shall be designed to prevent grout bleeding through and shall expand and mould itself to the shape of the void formed by the adjacent caisson nibs.
 - 6.2.2.2 Sock fibres shall be robust and not susceptible to damage during installation. The socks shall be supplied in a single length per void and no on site jointing or splicing is permitted.
 - 6.2.2.3 The exact size (diameter and length) of the sock shall be determined in accordance with the actual measured gap achieved between the caissons.

- 6.2.2.4 Grout sock to comprise A8 bidim or equivalent and shall be joined longitudinally in the direction of the longest length of the cavity to produce a cylinder.
- 6.2.2.5 The base end of the cylinder, created per 6.2.2.4 above, shall be sealed to create a closed end.
- 6.2.2.6 Joining methodology employed to achieve 6.2.2.4 and 6.2.2.5 above shall include double stitching of the bidim with a minimum 50mm overlap between seams. Seams are to include a canvas ribbon of both sides of the seam, with stitching passing through all layers comprising the seam/joint.
- 6.2.2.7 The primary material comprising the grout sock (A8 bidim or equivalent) shall have the following minimum material properties:

Table 6.2: Required Properties of Grout Sock / Geo-sock Material

Product:	Nonwoven, Needle punched, Continuous Filament, Polyester Geotextile			
Tensile Strength (200 mm wide strip)	In weaker direction	kN/m	50	BS EN 13251 EN ISO 10319
Elongation at maximum load	In weaker direction	%	50-70	BS EN 13251 EN ISO 10319
Resistance to static puncture	CBR test	kN	9.5	BS EN 13251 EN ISO 12236
Dynamic perforation resistance	Diameter of hole (max)	mm	6	BS EN 13251 EN ISO 13433
Normal Throughflow	Normal to the plane	l/s/m ²	30	BS EN 13251 EN ISO 11058
Permeability	Based on normal throughflow and thickness	X10 ⁻³ m/s	3.1	EN ISO 11058
Characteristic opening size	O _{95W}	µm	<75	BS EN 13251 EN ISO 12956
Durability	In accordance with the relevant clause of EN 13251, Annex B for service lives up to 50 years	-	-	BS EN 13251 Annex B

6.2.3 Stone fill to create platforms for return caissons

- 6.2.3.1 The stone used to create the platforms for the return caissons shall have the properties listed below. Except where noted, all testing shall be done in accordance with BS 812 series of standards for the assessment of aggregates.
- 6.2.3.2 Size, fines and uniformity
- 60 mm ≤ D₅₀ ≤ 75 mm.
 - D₈₅/D₁₅ ≤ 4.
 - Percentage fines (<0.063 mm) < 5%.
- 6.2.3.3 Density - The average density of the quarry stone shall be at least 2 700 kg/m³ with 90% of the stones having a density of at least 2 600 kg/m³.
- 6.2.3.4 Water Absorption - The average water absorption of the quarry stone shall be less than 2%, with 90% of the stones having water absorption less than 2.5%.
- 6.2.3.5 Strength and durability
- The aggregate impact value (AIV) shall not exceed 30 %.
 - The 10% fines aggregate crushing value (10%FV) shall be not less than 120 kN.
 - The aggregate abrasion value (AAV) shall not exceed 15 %.

6.2.4 Stone fill between caissons

- 6.2.4.1 The stone fill between adjacent caissons shall have the same properties as those prescribed in 6.2.3, except for the size, and uniformity which shall be:
- 19 mm ≤ D₅₀ ≤ 35 mm.
 - D₆₀/D₁₀ ≤ 5.
 - Percentage fines (<0.063 mm) < 5%.

6.2.5 Grout

6.2.5.1 All grout shall comply with the requirements of SANS 2001-CC1:2007 with particular reference to Sections 4.2.7 and 4.9.3.

6.2.6 Reclamation sand fill

6.2.6.1 The material for the sand filling of the caissons and for reclamation backfill between the caissons and the existing quay wall is specified in specification 1785-CO-000-C-SPC -0004 – Dredging and reclamation (Including Vibro Compaction).

6.2.7 Conveyor Belt

6.2.7.1 The construction and performance requirements of the conveyor belt, to be placed over inside face of seaside joint between caissons to prevent stone fill penetrating into gap between caissons, shall comply with ISO 22721:2017 *Conveyor belts — Specification for rubber- or plastics-covered conveyor belts of textile construction for underground mining*.

6.2.7.2 The conveyor belt will comprise a multi-ply arrangement, and with a minimum DIN quality rating: X or EN/ISO quality rating: H.

6.2.7.3 The conveyor belt to have high resistance to cuts, impact, abrasion and gouging.

6.2.7.4 Conveyor belt to be minimum 1000mm (1m) in width and shall extend the entire vertical length of the caisson joint.

6.2.7.5 For additional detail on placement of the conveyor belt, refer to drawing: 1785-CO-060-C-DWG-0031-01-T0A.

6.2.8 Drainage Strips

6.2.8.1 The drainage strips, to be placed over 200mm diameter drainage pipes, shall comprise a DN3, or equivalent, heavy-duty extruded HDPE drainage flownet.

6.2.8.2 The drainage strip shall be wrapped in A6 or equivalent bidim.

6.2.8.3 For additional detail on the drainage strips, refer to drawing: 1785-CO-060-C-DWG-0031-01-T0A.

6.2.8.4 The primary material characteristics of the drainage strips shall comply with the following minimum properties:

Table 6.3: Required Properties of Drainage Strips

Product Description:	HDPE Drainage Core		
Constituent Polymer	HDPE F 7650		
Vicat Softening Point	°C	70	ISO 306
Tensile Yield Strength	MPa	23	ISO 527
Overall Thickness @ 2kPa	mm	4	ISO 9863
Tensile Strength	kN/m	5	ISO 10319
Mesh Angle @ 5°	°	55	

6.3 Methods and Procedures

6.3.1 Filling, grouting and sealing

6.3.1.1 Filling, grouting and sealing of the caissons shall proceed as soon as any caisson has been accepted by the *Supervisor* in respect of its placement in position. The *Contractor* shall proceed with the operations in the accordance with the following sequence:

- a) Fit drainage strips and geo-textiles over drain pipe openings.
- b) Install rear grout sock and fill with 1 – 13 mm graded stone.
- c) Place filter fabric over land side joint between caissons
- d) Place conveyor belt over inside face of seaside joint between caissons to prevent stone fill penetrating into gap between caissons.
- e) Fill main gap between caissons with approved 19 – 35 mm graded stone fill and cover with filter fabric.
- f) Place approved sand fill material into the caisson by grab or pumping whilst monitoring the flow of

- displaced water at all times and ensuring that turbidity limits are not exceeded.
- g) Complete placement of all caissons including return caissons and infill panels for a particular phase.
 - h) Place backfill material for reclamation behind caisson to top of caisson level.
 - i) Vibro-compact caisson sand fill and back fill material.
 - j) Insert grout bag in front (seaward side) seal slot and inject grout.
- 6.3.1.2 Grouting shall be carried out with a suitable tremie tube placed so that the grout is injected from the bottom of the grout sock upwards under a controlled pressure in one continuous operation. Care shall be taken to ensure that the injection pressures are not so high as to cause bursting of the grout sock. Grouting shall be carried out in accordance with SANS 2001-CC1 Section 4.9.3.
- 6.3.1.3 The *Contractor* shall undertake a diver inspection with underwater video of the joints between the caissons over the full height to check integrity of grouted seal.
- 6.3.1.4 Construction and performance specifications for the filling and vibro-compaction of the caisson sand fill and reclamation fill behind the caisson are provided in specification 1785-CO-000-C-SPC-0004 – Dredging and reclamation (Including Vibro Compaction).
- 6.3.1.5 Drain pipes that penetrate through the caissons to discharge into the sea shall be temporarily sealed where they penetrate the caisson walls and adequately protected from damage during backfilling.
- 6.3.1.6 The *Contractor* shall ensure that the various filter fabrics, drainage strips and grout socks are not damaged during the placement of sand fill and stone fill. The *Contractor* shall ensure that stone and sand are not dumped directly onto areas where filter fabric is attached to the walls of the caisson and is instead dumped away from the walls such that the material flows or slumps relatively gently against the walls to avoid impact damage.
- 6.3.2 Quay wall monitoring**
- 6.3.2.1 The *Contractor* shall undertake monitoring of the caissons from time of placement until handover of the berth. Monitoring shall be undertaken using two methods, the primary method being electronic inclinometers and a secondary back up system being a surveyed baseline. Details of the proposed monitoring system are to be submitted by the *Contractor* to the *Supervisor* for acceptance.
- 6.3.2.2 The inclinometer system shall consist of an articulated chain of sensor elements (segments). The segments, each containing a multi-axial accelerometer, shall be interconnected in such a manner that they can move in relation to one another in all directions but shall not twist. The instrument shall be capable of following and presenting deformation and tilt with a resolution of 0.01 mm per 500 mm in the direction perpendicular to the quay wall. The accuracy, expressed as lateral deviation over a length of 30 m of casing shall be 6.00 mm x 30 m. The inclinometers shall be calibrated with a calibration tool after installation.
- 6.3.2.3 The inclinometers shall be mounted in casings firmly attached to the caisson. The inclinometer chain shall extend from the foundation level of the wall all the way up to the top of the caisson. The bottom end shall serve as a fixed reference point. Inclinometers shall be installed on the front face of each caisson at the mid wall.
- 6.3.2.4 The reading units that interrogate the sensors shall be housed in a central instrumentation room set up within the *Contractor's* on site offices. The data collected shall be processed on a PC using dedicated software in accordance with manufacturer's specification.
- 6.3.2.5 The instrumentation shall be capable of operating in temperatures ranging from 0°C to 50°C and shall be capable of operating in the wet and the dry.
- 6.3.2.6 Data collation and submission to the *Supervisor* shall be on a daily basis during caisson placement and reclamation and then shall revert to a weekly basis during capping beam and paving construction.
- 6.3.2.7 In addition to the inclinometer monitoring, the *Contractor* shall also establish a surveyed baseline in the form of steel pins inserted into the caissons along the entire length of the existing quay prior to any berth dredging works. The *Contractor* shall, on a twice-monthly basis, survey the baseline and shall compare the data with that obtained from the inclinometers to verify the electronic system.

7.0 PRECAST INFILL PANEL MANUFACTURE, LOAD OUT, TRANSIT AND POSITIONING

7.1 Method Statement

7.1.1.1 The method statements for this section shall include *inter alia*:

- a) Layout of casting yard for infill panel manufacturing.
- b) Details of formwork and casting beds for panel manufacturing.
- c) Details of methodology and Equipment for transporting panels from casting bed to position of load out.
- d) Details of methodology and Equipment for load out of panels.
- e) Details of methodology for sea fastening panels.
- f) Details of methodology and Equipment for towing of panels.
- g) Details of methodology and Equipment for positioning of panels.

7.2 Materials

7.2.1 Reinforced Concrete

7.2.1.1 All concrete works for the panels shall be in accordance with *Employer* specification 1785-CO-000-C-SPC - 0001 – Concrete for Marine Construction.

7.3 Equipment (Including Temporary Works)

- 7.3.1.1 The Lot 10 yard shall be used for construction of the precast infill panels for the caisson quay wall. The *Contractor* shall be responsible for establishing all casting beds required for the infill panels.
- 7.3.1.2 Precast Infill Panel formwork shall comply with the provisions of specification 1785-CO-000-C-0001 – Concrete for Marine Structures.
- 7.3.1.3 The *Contractor* shall provide all craneage and barges for lifting, transporting and placing infill panel units.
- 7.3.1.4 The Equipment for Lifting shall comply with the requirements of DNV-OS-H201, DNV-OS-H202 and DNV-OS-H205.

7.4 Methods and Procedures

- 7.4.1.1 The provisions of SANS 2001-CC1:2007 Section 4.8 - Precast Concrete and Section 4.10 Handling and erection of precast concrete units shall apply.
- 7.4.1.2 The infill panels shall be transported to site via a waterside operation. Landward transport of the units is not permitted.
- 7.4.1.3 The loadout operation (transfer of infill panels from land onto a barge) shall be planned and undertaken in accordance with DNV-OS-H201 with particular reference to Section 3.
- 7.4.1.4 The tow route shall be as per the route for the caissons as described above.
- 7.4.1.5 Towing shall be planned and undertaken in accordance with DNV-OS-H202 with particular reference to Section 4 and 5.
- 7.4.1.6 Lifting and positioning operations shall be planned and undertaken in accordance with DNV-OS-H205.

8.0 COMPLIANCE WITH REQUIREMENTS

8.1 Tolerances

The *Contractor* shall ensure that cumulative tolerances meet with tolerance requirements as defined within this specification.

8.1.1 Caisson construction

- 8.1.1.1 Deviations shall be within the limits listed in SANS 2001-CC1:2007 – Concrete works (structural) for Degree of Accuracy II, specified in clause 6, unless stated otherwise.
- 8.1.1.2 The caisson base formwork shall be set out on the casting base platforms entirely level, to an accuracy of ± 10 mm over the longest dimension of the base.
- 8.1.1.3 Once the caisson is moved to the interim beams, the base shall be level to within the same tolerance.
- 8.1.1.4 The walls shall be cast by the sliding formwork entirely vertically and at right angles to the base. In particular the sealing faces between caissons shall achieve an accuracy of ± 25 mm. The mating faces shall be straight to a maximum deviation of 5 mm over any gauge length of 2 m, with a total deviation from straightness of not more than 50 mm over the whole height.
- 8.1.1.5 Before a slide is started, reference points shall be established and verticality during sliding shall be measured, using laser equipment. Measurements shall be taken before sunrise to minimise the effects of thermal distortion of the slide and concrete.

8.1.2 Caisson placement

- 8.1.2.1 Caissons shall be placed to the following tolerances:
 - a) Gap between caisson mating faces 60 mm \pm 50 mm. Cumulative deviation shall be no more than 120 mm along the entire berth.
 - b) Deviation of front faces from theoretical straight line ± 75 mm.
 - c) Verticality of front face maximum 100 mm at top from plumb line passing through corresponding point at bottom over the full caisson height.
 - d) Height compared to theoretical top elevation of +2 m CDP shall be ± 150 mm.
 - e) In situ tolerances for adjacent caissons shall be such that mating surfaces for grout pockets remain fit for purpose, i.e. tolerances shall not be cumulative between adjacent caissons, thus rendering the grout pockets ineffective.

Note – Accumulation of tolerances with respect to dredging of foundation trench, placement of foundation stone bed, caisson manufacturing and caisson placement is not permitted.