



TRANSNET SOC LTD

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

PORT OF DURBAN

**SPECIFICATION – GROUND IMPROVEMENT: RIGID INCLUSIONS AND
FOUNDATION STONE BED (CAISSON LOAD TRANSFER PLATFORM)**

1785-CO-000-C-SPC-0010 Rev T-00

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**SPECIFICATION – GROUND IMPROVEMENT: RIGID INCLUSIONS AND FOUNDATION STONE BED
(CAISSON LOAD TRANSFER PLATFORM)**

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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 rigid inclusion ground reinforcement. The ground reinforcement in its entirety is composed of a compacted stone bed with geotextile at its base, both of which overly the in situ soil reinforced with a grid of rigid inclusions. This specification covers the materials, equipment, construction, tolerances and testing of the combined ground reinforcement.

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, Standards and 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-030 series thereof that detail the required Ground Improvement – Soft Piles

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.

Construction of the rigid inclusions and foundation stone bed shall comply with the following standard specifications, unless otherwise stipulated herein:

- a) BS EN 12699:2015 Execution of special geotechnical works – Displacement piles
- b) BS 6031:2009 Code of practice for earthworks
- c) BS 812 Method for sampling and testing mineral aggregates (or equivalent BS EN revision)
- d) BS EN 13251:2014+A1:2015 Geotextiles and geotextile-related products.
- e) PD CEN/TR 15019:2005 Geotextiles and geotextile-related products. On-site quality control
- f) BS EN ISO 22476-4:2012 Geotechnical investigation and testing.

2.3 *Employer's* Project Specific Specifications and Standards

Construction of the rigid inclusions and foundation stone bed shall also comply with the following Project Specific Specifications:

- a) 1785-CO-000-C-SPC-0001 – Concrete for Marine Construction
- b) 1785-CO-000-C-SPC-0002 – Caisson Construction and Placement
- c) 1785-CO-000-C-SPC-0004 – Dredging and Reclamation (Including Vibro Compaction)
- d) 1785-CO-000-C-SPC-0009 – Steel Sheet Piling
- e) 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 the “Engineer”, replace this term with the term “Supervisor”.

For the purpose of this specification, the definitions and abbreviations given in BS EN 12699, together with the following 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. The method statements shall be submitted to the *Supervisor* for acceptance three weeks in advance of the particular activity being undertaken. Full details of all proposed Equipment (including temporary works) and methods shall be provided for acceptance by the *Supervisor*.

No activity shall commence until the method statement has been accepted by the *Supervisor*.

Further requirements for particular method statements are specified herein below.

3.5 Airlifting

Airlifting refers to a dredging technique whereby soil is sucked from the seabed and transported upwards and away from its source.

3.6 Foundation Stone Bed (Load Transfer Platform)

The term “foundation stone bed” refers to a layer of compacted stone placed over geotextile on the seabed, also referred to as the “load transfer platform (LTP)”, upon which the caissons that will comprise the quay wall structure are to be placed.

3.7 Geotextile

This term refers to geotextile placed at the base of the foundation stone bed to maintain separation of such stone from the underlying sand to prevent mixing of the foundation stone bed and in situ soil, while still allowing the through flow of water.

3.8 Rigid Inclusion (RI)

The term “Rigid Inclusion” (RI) refers to a concrete column that is cast in situ within cylindrical voids formed in the soil primarily by lateral displacement with minimal or no excavation or removal thereof.

Where BS EN 12699 or other applicable specifications refer to “pile” or “displacement pile”, replace this term with the term “rigid inclusion”.

Where BS EN 12699 refers to “filling” this shall include techniques where concrete is pumped with a pressure higher than the hydrostatic pressure.

3.9 Steel Fiber Reinforced Concrete (SFRC)

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

3.10 Demonstration Rigid Inclusion

This term refers to a RI that is installed as part of a demonstration of a contemplated RI installation method, which is not taken to be part of the permanent Works.

3.11 Working Rigid Inclusion

This term refers to a RI that is taken to be part of the permanent *works*.

4.0 REQUIREMENTS

4.1 Method Statements

The *Contractor* shall prepare method statements that shall include *inter alia*, the following information:

1. Detailed description of the Equipment for all activities.
2. The *Contractor's* chosen methodology for installing rigid inclusions including the concrete mixing, delivery and filling methodology.
3. Sequence of construction for all activities.
4. How the planned RI cut off level and toe level are achieved with reference to the in situ materials described in Section 4.4.
5. Estimates of filling pressure required to achieve the required RI diameter (if applicable).
6. Predicted RI installation rates for driving and filling.
7. How the *Contractor* plans to meet the location and level tolerances described in Section 5.1.
8. Details of the rigid inclusion demonstration specified in Section 5.3.
9. Quality control program including certified test results and statements of quality for the materials.

4.2 Materials

4.2.1 Steel-Fibre-Reinforced Concrete (SFRC)

Steel-fibre-reinforced concrete shall be in accordance with Specification 1785-CO-000-C-SPC-0001 - Concrete for Marine Construction.

4.2.2 Stone

The stone used for the foundation stone bed shall have the properties specified below. Except where noted, all testing shall be done in accordance with BS 812 series of standards for the assessment of aggregates.

- a) Size, fines and uniformity
 - $60 \text{ mm} \leq D_{50} \leq 75 \text{ mm}$
 - $D_{85}/D_{15} \leq 4$
 - Percentage fines ($<0.063 \text{ mm}$) $< 5\%$

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- b) Density
The average solid density of the quarry stone shall be at least 2 700 kg/m³ with 90% of the stones having a solid density of at least 2 600 kg/m³.
- c) 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%.
- d) Strength and durability
- The aggregate impact value (AIV) shall be less than 30 %.
 - The 10% fines aggregate crushing value (10%FV) shall be not less than 120 kN.
 - The aggregate abrasion value (AAV) shall be less than 15 %.

4.2.3 Geotextile

Geotextile shall be placed at the base of the foundation stone bed. This shall be a high strength geotextile used for separation and filtration in construction of earthworks, foundations and retaining structures. The geotextile shall conform to the properties given in listed in Table 4.2.1 below.

Table 4.2-1 - Required Properties of Geotextile

Product:	Composite geotextile and geotextile related products			
Intended use	For reinforcement, separation and filtration, in construction of earthworks, foundations and retaining structures.			
Tensile strength (T_{MAX})	Machine direction (MD)	kN/m	200*	BS EN 13251 EN ISO 10319
	Cross machine direction (CMD)	kN/m	200*	
	Elongation (ε _{MAX})	%	10*	
	Creep limited strength (120 years)	kN/m	120*	BS EN 13251 EN ISO 10319
Resistance to static puncture	CBR test	kN/m	4.8*	BS EN 13251 EN ISO 12236
Water permeability	Normal to 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	To be declared in accordance with the relevant clause of EN 13251, Annex B	-	-	BS EN 13251 Annex B
Release of dangerous substances	Less than required by national regulations	-	-	National Regulations in force

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

Rolls of the geotextile are to be procured in as large a size as is available from the supplier in order to minimise the number of joints and/or overlaps.

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 the duration recommended by the manufacturer.

On site quality control shall be in accordance with PD CEN/TR 15019.

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The *Contractor* shall submit to the *Supervisor* certified test results and statements of quality that show without exception that the proposed geotextile meets the requirements of this specification.

4.3 Equipment

4.3.1 General

The *Contractor* shall take full and entire responsibility for the sufficiency of his Equipment to provide the *Works*. The *Contractor* shall submit details of all Equipment intended to be used to the *Supervisor* at least 3 weeks prior to commencement of the corresponding work.

The *Contractor* shall provide floating and/or other working platforms to support its Equipment that comply with the requirements for all marine Equipment specified in the Works Information.

4.3.2 Rigid Inclusion Equipment

The *Contractor* shall select a suitable installation method and Equipment to perform the RI construction, with due consideration for the in situ ground conditions described in Section 4.4 and elsewhere, capable of applying sufficient force, torque and/or energy necessary to penetrate to the specified RI toe level.

SFRC shall be placed using suitable pumping Equipment with means of determining the volume and pressure thereof.

A communication system shall be maintained between the RI rig operator and the SFRC pump operator at all times.

4.3.3 Foundation stone bed Equipment

The *Contractor* shall provide suitable Equipment for placement of the foundation stone bed, plus accurate levelling (screeding) thereof. Marine screeding equipment may include a travelling screed hopper, screeding beam, stone tremie tube, other specialist screeding equipment or a combination of these.

4.4 Nature of In Situ Material

The *Contractor* shall apply methodology and Equipment for installing the RIs that are suitable for the ground conditions described in the Project Geotechnical Reports, included in Part 4 - Site Information.

The *Contractor* is made aware of the presence of existing foundation trench material which includes 76 mm stone, which the selected Equipment shall be capable of penetrating without deviating out of tolerance.

4.5 Methods and Procedures

4.5.1 Rigid Inclusions

4.5.1.1 General

The RIs shall be installed by persons having relevant previous experience installing RIs in a marine environment.

4.5.1.2 Installation methodology

RIs shall be cast in situ in vertical cylindrical voids formed primarily by lateral displacement of the soil, by means of tools selected by the *Contractor* capable of penetrating the ground conditions revealed in the Site Information, to the full depths specified for such RIs on the contract drawings.

If it is necessary to carry out either jetting or augering to facilitate penetration of stiff or dense layers, such shall be performed in a manner as will limit loosening of the surrounding ground and will bring the resulting spoil up to the surface for disposal on land, excluding any from being deposited on the seabed or released into the water, by a method approved of by the *Supervisor*.

SFRC shall be pumped into the RI voids simultaneous with extraction of the tool utilized to form them in a single uninterrupted operation to fill up to the level of the seabed.

Drilling fluids are not permitted for keeping RI holes open.

4.5.1.3 Obstructions

The *Contractor* shall remove surficial obstructions, including existing scour protection rock (possibly up to 380 mm and 300 kg or greater), as part of the dredging works prior to commencement of RI installation.

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One of the following options shall be adopted as may be instructed or approved by the Supervisor in case of subsurface obstructions such as boulders, timbers, concrete, and/or bricks, etc. that cannot practically be penetrated by the RI displacement tool:

- a) Re-position the RI a short distance away
- b) Remove the obstruction
- c) Pre-drill the obstruction

The *Supervisor* shall be notified immediately of any obstructions or unexpected early refusal.

Dense or stiff soil shall not be considered as an obstruction.

4.5.1.4 Sequencing of works

The Rigid Inclusion works shall be undertaken after the dredging works and be followed by placement of the foundation stone bed. The RI installation sequence shall account for the nature of the in situ material and the curing time of adjacent rigid inclusions, as detailed in BS EN 12699. If adjacent, already cast RIs are observed to be influenced by the forming of subsequent neighbouring RIs, such as by the flow of still liquid concrete draining from the former, the *Contractor* shall modify the installation sequence to prevent further disturbance of RIs at no additional cost to the *Employer*.

Excavation as may damage the RIs shall not be carried out around or near them.

4.5.1.5 RI top level

The RI top level shall correspond to the level of the dredged foundation trench and slopes as shown on the 1785-CO-030-C series of drawings.

4.5.2 Foundation stone bed

4.5.2.1 Installation methodology

It is the *Contractor's* responsibility to select a suitable placement and screeding methodology that will meet the requirements of this specification.

4.5.2.2 Sequencing of the works

Following completion of installation of the RIs in any selected area, the *Contractor* shall prepare the foundation stone trench as follows:

- a) Remove any sediment exceeding 0.10m thick that may have accumulated after dredging on either the floor of the foundation trench and slope and/or over the tops of the completed RIs by airlifting.
- b) Place the specified geotextile and secure it by appropriate weighting.
- c) Remove any sediment exceeding 0.10m thick that may accumulate on top of the geotextile by airlifting.
- d) Place and compact the specified stone fill over the geotextile through tremie pipes or other suitable means.
- e) Screed the foundation stone bed to within the level tolerances specified in Section 5.1.3.
- f) Undertake a bathymetric survey to verify compliance with the level tolerances specified in Section 5.1.3..
- g) The *Contractor* shall submit the survey results to the *Supervisor* for acceptance of the *works* prior to placement of the caissons.

4.5.2.3 Geotextile placement

The specified geotextile shall be laid over the dredged seabed and completed RIs with care to avoid damage or puncturing, with adequate overlaps between adjacent sheets not less than 1.5m wide, or wider if necessary to accommodate possible displacement thereof as stone is placed above. Additional sheets of geotextile shall be placed to cover any gaps that might open between previously placed sheets, as shall be monitored by diver/observers, at no additional cost to the *Employer*.

4.5.2.4 Foundation stone bed placement

The stone for the foundation bed shall be placed such as neither to displace the geotextile sheets as may cause gaps to open between them, nor to cause local failure of the foundation trench slopes. The *Contractor* shall remediate any local slope failures by removing and disposing of any material associated with local slope failure, rectify any disruption to the geotextile, and re-establish the slope using foundation stone bed material. The remediated slope shall meet the level tolerances as specified herein below.

The foundation stone bed shall initially be filled to a level sufficiently above the specified design level such that after re-screeding the level finally complies with that specified, within the corresponding permitted tolerances.

4.6 Record Keeping

4.6.1 Rigid inclusions

The *Contractor* shall keep records of the following for each individual RI and submit these records to the *Supervisor*:

- a) Date and time of installation
- b) RI number
- c) Working level
- d) Final toe and top elevations
- e) Nominal cross-section diameter
- f) Seabed level and tide level (CDP) at commencement of installation of RI
- g) The applied torque, thrust, rate of penetration and revolutions per minute
- h) Rate of tool penetration with depth
- i) Details of any jetting or augering
- j) Rate of tool withdrawal with depth
- k) Rate of SFRC delivery to tool with depth
- l) The RI rig operator shall indicate on the daily drilling log for each RI that verticality was within tolerance
- m) All information regarding obstructions, delays and interruptions to the Work.

5.0 COMPLIANCE WITH REQUIREMENTS

5.1 Tolerances

5.1.1 General

Any deviations of plan positions and/or levels of caissons, the foundation stone bed, and dredging shall be measured by reference to the corresponding specified positions and levels for comparison to permitted tolerances, and not only relative to adjacent components (i.e. the accumulation of tolerances is not permitted).

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

5.1.2 Rigid inclusions

Deviations shall be within the limits listed in BS EN 12699, unless stated otherwise on drawings or elsewhere in the Works Information.

- a) Plan location $e \leq 0.50\text{m}$
- b) Level not more than 0.5m below the surrounding sea bed
- c) Inclination $i \leq i_{\text{max}} = 0.04 \text{ (0.04m/m)}$
- d) Cross-sectional diameter not less than specified on the applicable drawings

Plan locations and inclinations of RIs shall be taken as equivalent to that of the points where the RI displacement tool passes through the deck of the barge from which the work is carried out and recorded as such. The cross-sectional diameter of RIs shall be taken as that of the tool applied to displace the soil to form the void in which they are cast.

5.1.3 Foundation stone bed

The final foundation stone bed top level shall be within ± 150 mm of the level specified on the drawings. Differences in the upper level thereof between any two points shall not exceed 75 mm within any 10 m radius.

5.2 Surveys

5.2.1 Bathymetric surveys

The project bathymetric survey requirements are detailed in specification 1785-CO-000-C-SPC-0004 - Dredging and Reclamation.

The caisson scour trench (the “berth pocket”) shall be surveyed after it has been dredged to confirm compliance with the specified design thereof.

The top of the foundation stone bed shall be surveyed after completion of screeding thereof to confirm its compliance herewith.

The out-survey for the berth dredging for the caisson scour trench (berth pocket dredging) shall form the in-survey for the RI and foundation stone bed works.

On completion of the Works an out-survey is required of the final foundation stone bed top level.

5.2.2 Dive surveys

Dive surveys shall be undertaken by the *Contractor* to verify that any excess thickness of soft or loose sediment that may have settled on the bottom of the dredged caisson scour trench has been removed, as specified herein above, prior to placement of the specified geotextile, and again prior to placement of the stone. Verification shall be carried out by probing measurements and video footage.

The gridlines and RI positions shown on the drawings shall be used as a reference system for such dive surveys and reporting. The *Contractor’s* dive team shall setup a system whereby a diver may be positioned accurately with respect to these gridlines.

The *Contractor* shall submit a dive survey report with video footage along each gridline (No. 1 to No. 63) filmed just prior to commencement of placement of the geotextile, and again just prior to placement of the foundation stone bed. Such reports shall include dates and locations of dives, the names of the divers and dive *Supervisor*, summaries of the dive survey results, any other relevant observations, and probing measurement

5.3 Practical Demonstration

5.3.1 Rigid inclusion installation demonstration

The *Contractor* shall demonstrate the effectiveness of the proposed method of installation of RIs by installing at least four (4 No) RIs in the apparently least favourable ground conditions (including near to exploratory boreholes BHS04 and BHS02), before commencing installation of the working RIs, to verify that the *Contractor’s* chosen methodology complies with the requirements hereof, including in particular the following:

- a) cross sectional diameter
- b) toe levels
- c) Pumpability of SFRC over distances representative of those expected to be applied to the working RIs.

The demonstration RIs shall be installed prior to the basin dredging *works*. The top levels of the demonstration RIs shall conform to the existing seabed level prior to basin dredging, while the toe levels shall correspond to the specified toe levels of the nearest working RIs. The *Contractor* shall make provision for excavation of the seabed material around the demonstration RIs to a depth of -18.35 m CDP. The demonstration RIs shall be cut off at -18.35 m CDP and the upper sections brought to the surface in suitable lengths for inspection and subsequent disposal. The *Contractor* shall label each cut off section according to the number and depth of the corresponding demonstration RI (i.e. such as



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BHS04:1-0m-2m). Once on land the cross-sectional diameter of the sections shall be measured at 0.2 m intervals along its length.

The *Contractor* shall submit a report to the *Supervisor* detailing the demonstrations, measurements and calibrations prior to undertaking any working RIs.

The *Contractor* shall apply the results of the demonstration RIs to confirm or correct their methodology for the working RIs such as to ensure compliance herewith.

End of Specification
